O‘ZBEKISTON RESPUBLIKASI

OLIY TA’LIM, FAN VA INNOVATSIYALAR VAZIRLIGI

FARG‘ONA DAVLAT UNIVERSITETI

FarDU ILMIY XABARLAR-

1995-yildan nashr etiladi
Yilda 6 marta chiqadi

2-2023

НАУЧНЫЙ ВЕСТНИК. ФерГУ

Издаётся с 1995 года
Выходит 6 раз в год

BIOLOGIYA

UDK: 577.121.7.612.51 **DOI: 10.56292/SJFSU/vol29_iss2/a138**

DIFFERENCE IN THE AEROBIC METABOLISM OF WARM AND COLD-BLOODED ANIMALS: IMPORTANCE IN THERMOGENESIS

РАЗНИЦА В АЭРОБНОМ МЕТАБОЛИЗМЕ ТЕПЛОКРОВНЫХ И ХОЛОДНОКРОВНЫХ ЖИВОТНЫХ: ЗНАЧЕНИЕ В ТЕРМОГЕНЕЗЕ

ISSIQQONLI VA SOVUQQONLI HAYVONLARNING AEROB METABOLIZMIDAGI FARQ: TERMOGENEZDAGI AHAMIYATI

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Abstract

It was discovered that cold-blooded species of animals (steppe turtle, sheltopusik (Pallas' glass lizard) and water snake) have a very low aerobic metabolism, the level of which is about 10 times lower than that of warm-blooded rats. These data are consistent with literature data obtained on other animals. According to the modern literature, warm-blooded animals, when performing various physiological work, expend more energy than cold-blooded ones. Therefore, it is assumed that the body to maintain the warm-bloodedness spends a significant part of the metabolic energy.

Аннотация

Выявлено, что у хладнокровных видов животных (степная черепаха, Желтопузик (стеклянная ящерица Палласа) и водяной уж) очень низкий аэробный метаболизм, уровень которого примерно в 10 раз ниже, чем у теплокровных крыс. Эти данные согласуются с литературными данными, полученными на других животных. По данным современной литературы, теплокровные животные при выполнении различной физиологической работы расходуют больше энергии, чем хладнокровные. Поэтому предполагается, что организм на поддержание теплокровности тратит значительную часть метаболической энергии.

Annotatsiya

Sovuq qonli hayvonlar turlari (dasht toshbaqasi, Jeltopuzik (Pallas kaltakesagi) va suv iloni) juda past aerob metabolizmga ega ekanligi aniqlandi, ularning darajasi issiq qonli kalamushlarnikidan taxminan 10 baravar past. Ushbu ma'lumotlar boshqa hayvonlar haqida olingan adabiyot ma'lumotlariga mos keladi. Zamonaviy adabiyot ma'lumotlariga ko'ra, issiq qonli hayvonlar turli xil fiziologik ishlarni bajarishda sovuq qonli hayvonlarga qaraganda ko'proq energiya sarflaydi. Shuning uchun organizm metabolik energiyaning katta qismini issiq qonlilikni saqlashga sarflaydi, deb taxmin qilinadi.

Kalit so'zlar: *termogenez, sovuq va issiqqonli hayvonlar, metabolizm, gaz almashinuvi, kislorod iste'moli, tana harorati, aerob metabolizm, mitoxondriya.*

Ключевые слова: *термогенез, холоднокровные и теплокровные животные, обмен веществ, газообмен, потребление кислорода, температура тела, аэробный метаболизм, митохондрии.*

Key words: *thermogenesis, cold and warm-blooded animals, metabolism, gas exchange, oxygen consumption, body temperature, aerobic metabolism, mitochondria.*

INTRODUCTION

In this work it is compared the metabolism of warm and cold-blooded animals. In the literature, in this regard, these groups of animals are rarely compared, and the research results are not of great interest among physiologists. Need to say that according to the available data, these groups of animals differ significantly (5-10 times) in the level of metabolism and heat production [1-6]. Perhaps the indicated metabolic difference between animals is a common feature for all animals living in different climatic conditions, including Central Asia.

The difference shown by physiologists is explained by the action on the body of various environmental factors, without going into the metabolic and physiological essence of the state of warm-bloodedness.

Further, this research raises an important question about the physiological role of metabolic differences between these groups of animals. A specific question should be raised - why do warm-blooded organisms consume about 10 times more energy than cold-blooded ones? According to a number of scientists, this metabolism determines the effective adaptation of animals to the environment [1-6], as well as their high reproductive activity [3].

One of the possible reasons for the high aerobic metabolic rate in warm-blooded animals may be associated with thermogenesis, which is necessary to ensure the warm-blooded status of the organism. However, until now, neither physiologists nor biochemists have raised the issue from such an angle and little attention has been paid to the mechanism of this difference.

Usually, heat production in the body of animals is explained by the low efficiency of biological processes [7-9]. Only a few studies have noted the existence of a special form of respiration – uncoupled respiration at the mitochondrial level, which converts oxidation energy directly into heat [11-13]. This statement is unique and important for further investigation of the mechanism of tissue thermogenesis.

The afore mentioned literature data served as prerequisites for a broader and more comparative analysis of metabolism in body and cold-blooded animals.

MATERIALS AND METHODS

Installation for oxygen consumption measuring by the whole organism. In this case, the intensity of the total (gas-oxygen) exchange was measured by the polarographic method using a platinum electrode. The measuring (respiratory) installation included a chamber (plastic can) with a volume of 200-1000 ml of air. The animal was placed in this chamber and hermetically sealed. This chamber is connected to a micropump through plastic tubes, and communicates through tubes with a platinum electrode that measures the oxygen content in the chamber with the animal (Fig. 1). The micropump allows air to circulate in a measuring installation, isolated from the outside air [20].

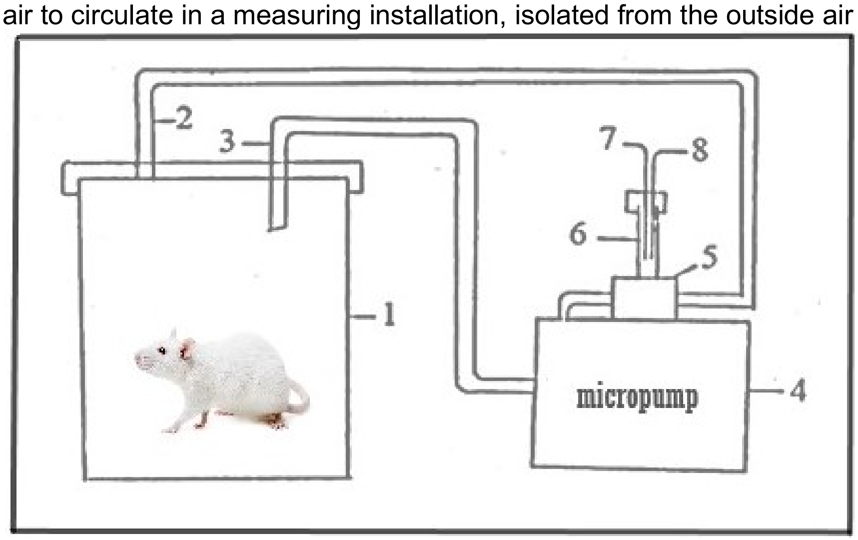

Fig. 1. Installation for oxygen consumption: 1 - a chamber with an animal; 2 - outlet tube; 3 - inlet pipe; 4 - micro pump for air circulation in the system; 5 - compartment; 6 - Clark electrode; 7 - output of the platinum electrode; 8 - output of chlorinated silver electrode

As the animal breathes in the measuring chamber, oxygen will decrease, which will be measured by a polarograph. The intensity of oxygen consumption mainly depends on the warm- and cold-blooded status of the animals used in the experiment.

Animals of Central Asia, used in the experiments. White laboratory rats (*Rattus norvegicus*) were used in the experiments.

The rest of the animals were caught in the steppes of Qarshi and Namangan: yellow ground squirrels (*Spermophilus xanthoprymnus*), steppe turtles (*Testudo horsfieldi*), sheltopusik (*Pseudopus apodus*), water snakes (*Natrix tesselata*), marsh frogs (*Pelophylax ridibundus*).

After capturing these animals, they were kept in a vivarium with an indoor temperature of about 30°C. The capture of animals was carried out in May-July, when the air temperature during the day warmed up to 30°C. In the vivarium, conditions were created for all animals close to those of the steppe. Feeding was done in the same way, taking into account the nutritional characteristics of each animal in nature. Studies on these animals were carried out within a month after their capture.

RESULTS AND DISCUSSIONS

Characteristics of animals and the study of the gas exchange intensity. First, the weight of the animals was determined. We used rats for comparison with field animals. We used five species of field animals caught in Uzbekistan (table 1). These animals differ in mass from two to four times, where the water snake has the smallest mass.

Table 1. Metabolism rate in warm and cold-blooded animals (It is presented in ml O_2 per kg/h).

Animal species	Average mass, g	Body temperature, °C.	Metabolism rate ml O_2 kg^{-1} h)	Difference (at times)
Rats	180.2	37.2	1193,3 ± 281,4	
Yellow ground squirrels	325.7	36.9	980,5±97,4	1.2
Steppe turtles	438.3	30.3	77,9 ± 4,6	15.3
Sheltopusik	215.6	30.4	121,8 ±7,2	9.8
Water snakes	150.3	30.3	92,7±7,3	12.7
Marsh frogs	55.3	30.2	132,4±5,4	8.1

Note: Animal metabolism was measured in a respiratory chamber [20], where the oxygen content in the air was taken as 21%, which closely corresponds to the oxygen content in the air. The temperature in animals was measured at 36 30°C in the environment

The next indicator measured in animals is their body temperature. It must be said that these animals were kept in a vivarium, the temperature of which during the spring studies was maintained at a level of about 30°C. As can be seen from the table. 1, the body temperature in cold-blooded animals closely corresponds to the ambient temperature.

In warm-blooded animals, the body temperature (about 37°C). The above shows that body temperature is one of the important criteria for establishing the warm-blooded status of animals. Their body temperature is near to the ambient temperature.

It was revealed that the laboratory rat and the ground squirrel differ little in metabolism as warm-blooded organisms. However, when comparing warm and cold-blooded organisms, one can see large differences in the level of metabolism.

Further, the metabolism was studied in a comparative aspect in different animals, where the indicator was the intensity of oxygen consumption by the body.

We were interested in the question of the difference between warm and cold-blooded organisms in terms of metabolism. Such studies have not previously been carried out on Central Asian animals living in arid zones. In general, it is interesting to what extent these animals correspond to the established principles of metabolic physiology, carries out earlier [1-6]. Our results showed that the cold-blooded species of animals used in our research, the metabolic rate is much lower than that of warm-blooded species. According to Table 1, warm-blooded animals have an eight to 15 times higher metabolic rate than cold-blooded animals. Consequently, the difference in metabolism between warm and cold-blooded organisms established in our experiment corresponds to the metabolic norms described earlier [1-6].

We also made a graphical comparison of the difference in metabolism between the used animals (Fig. 2) from which it follows that cold-blooded organisms have about ten or more times lower metabolic rate than warm-blooded ones. The exchange in desert turtles is especially low in comparison with the exchange of warm-blooded ground squirrels, where the exchange of the former is eight, three times lower.

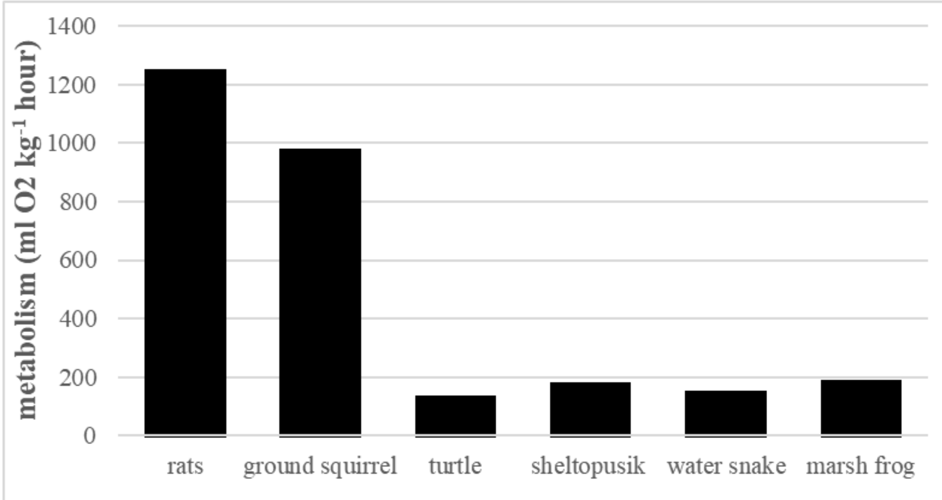

Fig 2. Differences in aerobic metabolism between warm and cold-blooded animals. The exchange values are presented in ml O_2 per kg/h.

When compared with a laboratory warm-blooded rat, there is a higher difference. In particular, the difference between a rat and a steppe turtle reaches 15.3 times, and the difference between a rat and a sheltopusik reaches 9.8 times.

It can be noted that there are large differences not only in terrestrial animals (turtles, ground squirrels), but also in aquatic animals, of which we used a water snake and a marsh frog, in which the metabolic rate is 12.7 and 8.1 times lower than in laboratory rats. As can be seen from the data presented (Fig. 2), in cold-blooded organisms, the metabolic rate is significantly lower than in warm-blooded ones. Moreover, a high difference in the level of exchange takes place between all used warm and cold-blooded animals.

CONCLUSIONS

Metabolism was determined in warm and cold-blooded animals living in Uzbekistan, adapted to land and water life. The data obtained correspond to the literature data on low metabolism in cold-blooded animal species. According to the literature, the difference between these groups of organisms is within 8-10 times [1-7]. Our results are consistent with the literature and indicate a greater difference between them. For example, according to our data, a turtles from a ground squirrel differs by up to 9 times in a lower metabolic rate. Compared to turtles with rats, the differences increase more than 15 times. It is possible that such a difference in steppe turtles is due to their ecologically slow way of life. However, it should be said that environmental conditions have little impact. In general, our results are consistent with the above literature and show that cold-blooded organisms are characterized by their existence at a low metabolic rate.

When analyzing the results obtained, it should be noted to one circumstance. These results were obtained at the same body temperature of the animals. It is known from physiology that a difference in 10°C leads to an approximately two to threefold increase in the difference in the measured indicator. However, we used animals with approximately the same body temperature and at the same ambient temperature. The literature also drew attention to this issue and determined the exchange of animals at different, as well as at equal temperatures, the environment according to Hulbert (1980).

A number of physiologists] for a long time did not pay attention to cold-blooded animals and believed that, in general, in the animal world, metabolism proceeds with a low efficiency [7-9]. However, the data obtained on the low level of metabolism in cold-blooded organisms [1-6] had important consequences - on the possibility of using metabolic energy with high efficiency in the body of cold-blooded animals than in warm-blooded animals. Experiments have shown [17-19] that the efficiency of energy use in cold-blooded animals when performing work was 2-4 times higher than in warm-blooded animals. Consequently, their low metabolism can have a certain physiological significance. In particular, in cold-blooded animals, the exchange may not be associated with heat production. In warm-blooded animals, on the contrary, a high level of metabolism can be associated with heat production.

The analysis of mitochondrial respiration allows saying that phosphorylating and uncoupled respiration functions in the mitochondria of tissues of warm-blooded animals [10-13], where uncoupled respiration can be involved in thermogenesis for ensuring body's warm-blooded state. Proton leakage may be involved in this process [14-15].

The results presented in the work indicate that high aerobic metabolism is the main tissue link of thermogenesis that ensures the warm-bloodedness state of the body.

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