Thermobiological Characteristics of Pikas, Rabbits and Rats

Mitsuo KOSAKA[1], G-J YANG[2], James N.C. PIAD[1], Jeong-Beom LEE[1], Yu CAO[1], Masaki YAMAUCHI[1], Eiko KANEDA[1], Takaaki MATSUMOTO[1], Nobu OHWATARI[1] and Akio SAKAI[3]

[1] *Department of Environmental Physiology, Insttitute of Tropical Medicine, Nagasaki University, Nagasaki 852−8523, Japan*
[2] *Center of Experimental Animal, Capital University of Medical Sciences, Beijing, China*
[3] *Department of Sports Medicine, Center for Research and Adaptation, Shinsuo University, School of Medicine, Matsumoto 390−8621*

Abstract: Animals are provided by nature with biological defense mechanisms against the deleterious effects of the environment. Three different animal species: pikas, rabbits and rats were compared in their thermobiological characteristics. Results revealed significant dissimilarities of the characteristics of pikas from both rabbits and rats that they called morphologically and physiologically unique. Compared to the two, these animals have relatively high body temperature and absence of circadian rhythm in core body temperature. These probably explain the non-manifestation of thermal panting and salivation which are evidences of the absence of natural heat losing ability in these animals. Since 1975 up to the present blood glucose has never been studied in pikas. Thus, in this experiment, this substance was determined to explain some biochemical related peculiarities in these animals. Findings revealed a low blood glucose level in pika in contrast to the rats but relatively similar to that of the rabbits. Conclusively, pikas have peculiarities which enable them to exist in environments with low temperature. It seems that blood glucose does not bear any relationship with this physiological nature. The same characteristics make them different from Lagomorpha and other lower animals.

Key Words: Lagomorpha, Circadian rhythm, Core body temperature, Blood glucose

INTRODUCTION

Animals have certain morphological/ physiological characteristics which enable them to exist in their respective environments. Pikas, which belong to genus Ochotona seem unusual among the Lagomorpha because of their distinctive physiological characteristics. These

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animal live above timber line or in cold zone (Kawamichi, 1985) or in high mountain ridges, such as the Himalayas, Alaska, Manchuria, Rocky and Ural mountains (Goodwin, 1968). Distribution however, is not limited to high altitudes. They have also been reported in places just about 10 m. above sea level (Sakai, et. al., 1988). They are intolerant to heat (Smith, 1974; Yang, 1990) that even during summer the temperature of their burrows is about 12℃ to 14℃ (Haga, 1960). Compared to rabbits and the rats, their body temperature and metabolic rates are higher (Kosaka, et. al., 1985). Heat dissipation may be occurred in the abdomen where the skin is thin and blood flow is increased in opposition to rabbits and rats sa well (Shimazu, et. al., 1993). Their hairs are longer and more dense (Luo, et. al., 1996). Except for a slight increase at dawn and dusk, neither diurnal nor nocturnal body temperature fluctuation was observed in them. This is in contrast to the robust nocturnal rhythms seen in rabbits and rats (Luo., et. al., 1996).

This experiment was aimed to determine the blood glucose level that would further characterize the thermobiological nature of the animals, pikas, rabbits and rats, with regards to cold climate adaptation.

Materials and Methods

Three kinds of animal species were used in this experiment: pikas (n = 6), rabbits (n = 6) and rats (n = 12). The pikas were reared at the Center of Experimental Animal, Capital University of Medical Sciences, Beijing, China. They were captured from the high mountains (3260 m above sea level) of Xinhai, in northwest China where the experiment on these animals was also done. Results of this study were compared with that obtained from the other two animals. Experimental procedures on the latter were conducted here at the Institute of Tropical Medicine. The rabbits and rats used here were reared at the Animal Center of the Institute of Tropical Medicine, Nagasaki University, Japan. The "Guideline for the Animal Experimentation"(Nagasaki university, 1989) and the "Principles for the Care and Use of Animals in the Field of Physiological Sciences"were followed in this experiment. During the process, the animals were kept in the individual steel cages at 22℃ with a 12L: 12D light dark photoperiod, with lights on at 8:00 AM and off at 8:00 PM. Tap water and special feed (Matsuzaki, et. al., 1980) were provided ad libitum. Circadian rhythms of body temperature were observed. A small amount of blood was collected from the retroauricular veins of the ear lobe of each animal for biochemical determination. A disposal finger lancet was employed to reduce possible painful sensation to the animals. Blood glucose was determined by putting about 10 ul. of blood to a Glu-test sensor (a small eletrode for measurement of blood glucose), which was inserted into the blood glucose test meter (Kyoto Daiichi Kagaku, Kyoto, Japan) for about 30 – 60 sec. The principle in this method involves the electro-chemical two step reactions, reduction and oxidation. With reduction, the *D*-glucose in the blood is reacted with potassium ferricyanide which is converted to potassium ferrocyanide and gluconic acid with the action of glucose oxidase. Then, with oxidation response, potassium ferrocyanide together with an eletro-chemical response are produced. The electric current generated stimulates the indicator which corresponds to the level of blood glucose. The experimental procedures were done at the same time of the day to prevent possible wide variation of results. The new set of data (Table 2) were used together with the previous collections (Table 3 & 4), to further compare the thermobiologic characteristics of these animals.

Data were expressed as mean values ± SD and were analyzed using Student's t-test and ANOVA at the presumed significance level of $p=<0.05$.

RESULTS

This is the first that a study on blood glucose has been made on pika although a number has been done on rabbits and rats detected from data bank by using Computer. (Table 1). This study is a preliminary of the series that will be conducted on this animal. In this experiment, among the three animal species that were subjected to glucose examination, rats have the highest blood glucose level ($p<0.05$). Though rabbits (body weight) were the biggest of them all, their blood glucose levels did not differ significantly (Fig. 1) from those of pikas which were about 6 to 7 times smaller (Table 2). Comparatively, their size did not determine the blood glucose levels. But among them, pikas have the unusual characteristics. Previous study has shown that pikas are intolerant to heat as compared to either rabbits or rats (Yang, 1990). While it was revealed that rabbits have strong panting (Table 3) and rats with weaker ones, in pikas these were absent. With salivation, rats manifested the heaviest

Table 1. Comparison of Studies on Glucose/Blood Glucose in Different Animals

	1995−1998	1990−1994	1985−1993	1976−1984	1966−1975
pika	6	7	17	21	18
pika + blood glucose	0	0	0	0	0
rabbit + blood glucose	11	19	28	25	5
rat + blood glucose	194	297	230	308	53
pika + glucose	0	0	0	0	0
rabbit + glucose	298	550	556	772	186
rat + glucose	3145	4531	4254	5196	1332

Table 2. Blood Glucose Levels of Pikas, Rats and Rabbits

	Body weight (grams)	Blood glucose (mg/dl)
Pika (n=6)	125−135	95±7.2
Rat (n=12)	600−620	109.1±14.1
Rabbit (n=6)	900−1200	96±6.8

while rabbits only a mild one. This however, was not observed in pikas. In terms of anatomical characteristics, ears of rabbits are much wider than pikas, so that the ear surface body ratio is greater in the former than in the latter. In both rats and rabbits, heat shock proteins were induced by shock in the previous experiment but were not in any tissues of the pikas. Table 4 shows additional data that were collected in China. These were gathered while

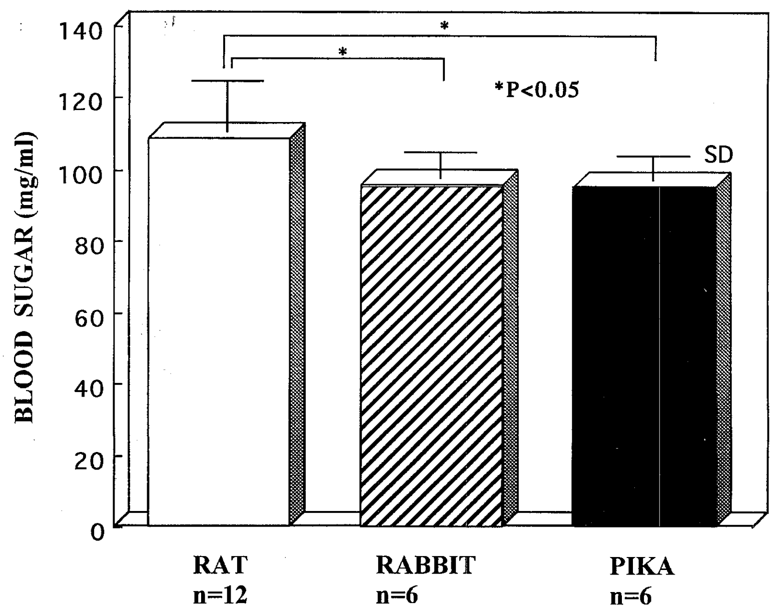

Fig. 1 Comparative graph of blood glucose of rats, rabbits and pikas

Table 3. Comparative Morphological and Physiological Characteristics of Pikas, Rats and Rabbits (Kosaka, et. ai., 1992)

	Pika	Rat	Rabbit
Rectal temp. ′C	39.4+0.2	38.0±0.4	38.9±0.3
O2 cons. ml/kg.min	23±2	26±3	9±2
Resp. rate	120±4	105±5	85±5
Thermal panting	−	+	+++
Salivation	−	+++	+
Ear/body surface ratio, %	7.2		17
Behavioral thermoregulation	+++	+	+
Sensitivity to pyrogens	+	+	++
Sensitivity to anesthetics	++	+	+
Heat shock proteins	±	+	+
RBC (×10/ul)	750±50	690±10	650±50
MCV (U)	51.0±0.5	53±2.3	60±1
Hematocrit, %	38±1	45±1	40±1
Circadian rhythm	−	+++	+++

Table 4. Physiological Characteristics of Pikas. Wt: body weight, length: body length, Tre: rectal temperature, RR: respiratory rate, Hct: hematocrit, RVW: right ventricular weight, TVW: total ventricular weight (Unpublished data of Capital University, Beijing, China)

No.	Sex	Wt(g)	Length(cm)	Tre(°C)	RR(/min)	Hct(%)	RVW(mg)	TVW(mg)
1	male	141.5	17	39.2	120	39.7	105	475
2	male	121	16	39.2	120	33.7	95	470
3	male	141.5	18	39.5	124	44.1	98	505
4	male	139.5	16	39.8	108	43.4	112	510
5	male	113.3	14	39.7	112	30	110	520
6	male	115.6	15	39.9	116	39	106	472
7	male	142	17				98	435
8	male	138	17				98	445
Mean±SD		131.6±12.6	16.3±1.3	39.6±0.3	116.7±5.9	36.7±6.6	102.5±6.6	479±30.6

the animals were still in high altitude. It can be observed that their physiological characteristics did not differ much from those gathered at sea level (Table 3). The core body temperature of pikas was maintained at about 39℃ even though they were at low lands (Tables 3 & 4) where the environmental conditions are unstable and where temperature fluctuates widely. Respiratory rate which was about 120/min was also at about the same level as when they were in the mountains (Table 4). Hematocrit values did not vary much with altitude. Total ventricular volume and right ventricular weight were not however considered in other two animals.

Discussion

The morphological and thermophysiological results obtained in this experiment suggest characteristics peculiar only to animals with respect to the conditions of their habitats. In the case of pika, it is thought that their rounded ears, moderate pyrogenic responses, high metabolic rate, high body temperature and poor heat dissipating ability are ecological adaptations to cold temperature of their environment (Kosaka, et. al., 1992; Yang, et. al., 1990). In contrast to other animals, pikas do not hibernate (Haga, 1958; Dawson, 1981); thus, they need to have biological protective mechanisms to allow them to survive in cold environments. Pikas are less capable of dissipating heat from their body, the reason may be that their abdominal skin is thinner than other animals (Shimazu, et. al., 1993). This can be explained by the absence of heat losing mechanisms such as panting and salivation (Yang, 1988). Rabbits exhibit active panting but the rats though weaker compared to rabbits, manifested heavy salivation which seem to compensate for the less active panting in this animal. When pikas were subjected to high ambient temperatures, their body temperatures kept increasing following the increase in experimental temperature. In rabbits, the core body temperature was well regulated. This suggests that pikas' body temperature mechanisms are already adapted to cold environments and should further increase in temperature is done, their physiologic functions will break down. This finding also correlates with the result of the previous study, in which there was difficulty of inducing heat shock proteins which relate to heat tolerance of pikas (Kosaka, et. al., 1992). Respiratory rate also did not increase against elevation in temperature. The pikas in comparison with rabbits and rats did not show circadian temperature rhythm, except for a slight rise at dawn and at dusk confirming the observation in previous studies (Luo, et. al., 1998; Kosaka, et. al., 1985). In rodents, a reduction in the amplitude of circadian rhythm was reported (Refinitti, et. al., 1990) and was also observed in man (Touitou, et. al., 1986) when they reach old age. So far as yet, there is no study about the blood glucose level in pika although there were several conducted in other animals. On rabbits and rats, the results were a bit higher than the present experiment because of the following reasons: 1) blood sample collection was made at a different time, 2) the animal subjects used were still young, as the blood glucose levels gradually decreases with age (Sato, 1992). The blood sugar, which is the main target in this study in pikas, was significantly lower than in rats although relatively, it was not significantly different from that of the rabbits. On the basis of the difference between pikas, rabbits and rats with regards to this biochemical property, it can be inferred that the first two, belonging to the same order, Lagomorpha, would seem to have similar blood sugar level. The difference in high body temperature and high metabolic rate, however, can not be explained on this basis; rather, on the environmental conditions where both animals habituate. It seems that glucose does not have any significant role in the control of body temperature of pikas. Although it can be presumed, that in way, it helps in the temperature regulation considering that pikas have high metabolic rate compared to other two animals. Rabbits and rats, unlike pikas, live in low lands where temperature is unstable. Hence, to adapt themselves to the changing environmental conditions, their body core temperature should also fluctuate in accordance with their surroundings. Pikas in contrast, since they habituate in cold climates, should maintain certain temperature level to protect themselves from the harsh environmental conditions. Comparison of results obtained from experiments conducted in high lands with that in low lands does not bear any significant diference.

Conclusively, pikas are unique animals which are naturally provided with biologically adaptive mechanism which serves as a shield against the deleterious cold temperature of their environmental. Blood glucose does not seem to play a significant role in core body temperature regulation in pikas. These animals in general can be the best subject for studies on physiological adaptations to cold temperatures.

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