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Studies of Temperature Regulation on Pika (*Ochotona rufescens rufescens*) ; An Old-fashioned Rabbit

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Abstract: Pika (family *Ochotonidae*, not *Lepordae*) provided from Central Institute for Experimental Animals, in Kawasaki city, has been reared individually at 22–23°C in P_2-facilities, in Animal Research Center in Institute for Tropical Medicine, Nagasaki University. Pika, the so-called a living fossil seems to preserve its morphological characteristics of those days of Eocene epoch in the Tertiary period. Namely, their lacking of ear radiator and strong long hind legs are thought to be evolutionally undeveloped. Therefore, the objective of the present report is to estimate the capability of pika, in heat loss and heat gain mechanisms in hot and cold environment. Mean rectal temperature was 39.6°C and mean respiratory rate was 131c/min, with no statistical significance in sexual difference. At 25°C of ambient temperature, O_2-consumption (Vo_2) was 19.8ml/min • kg and respiratory rate was 120–130c/min. At 15°C, Vo_2 was 32.0ml/min • kg and respiratory rate was decreased to 86–92c/min. At 29°C of high ambient temperature, Vo_2 showed increased value of 27.9ml/min • kg, with 200–230c/min of respiratory rate. From these results, physiological evidences of thermal adaptation relation to evolutional changes of thermoregulatory mechanism of pika were discussed in this paper.

Key words: Pika, Rectal temperature, Oxygen consumption, Respiratory rate, Temperature regulation, Thermal acclimatization

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INTRODUCTION

Pikas belong to the family *Ochotonidae* (not *Leporidae*) in the order *Lagomorpha*, although they have short rounded ears and their weights are less than 300g. Members of the genus *Ochotona* live above timber line or cold zone or in high mountain ridges such as Himalaya, Alaska, Manchuria, Rocky Mountains, and Ural Mountains (Goodwin, G. G., 1968). In Japan, pika is found near the summit of Mt. Daisetsu in Hokkaido. They have greyish soft coats and their hind legs are a little longer than fore legs.

Pika is considered to be "a living fossil" of Eocene epoch in the Tertiary period, which preserves morphological characteristics of those days for more than 40 million years. Their lacking of ear radiator and strong hind legs are thought to be evolutionally undeveloped.

The climate of early Tertiary period (65-25 million years) was hot and high humidity with decreasing temeprature in later epoch. It was very warm up to latitude of 50 degree. The beginning of the Tertiary period is known to be the era for flourishing of mammals when the age of dinosaurs had ceased already.

We don't know true distribution of the predecessor of Pika in those days, however, contemporary Pika is rarely seen in warm climate areas, which provides us several interesting questions; in what kind of environment it used to live, and whether their ability to live in cold places nowadays was already presented in early Tertiary period or originally developed in later period such as the Age of Ice. These problems are attractive not only for evolutionalism but also physiological interest.

The aim of this preliminary report is to estimate the capability of Pika in heat loss and heat gain mechanisms in hot and cold environment in relation to their evolutional changes of body temperature regulation.

MATERIALS AND METHODS

1. *Following up of growth of pikas*

Twenty pikas, 3 weeks old, weighing 80-90g, were provided from Central Institute for Experimental Animals. They were reared individually at 22 to 23°C under relatively aseptic condition of P 2 -facilities. Weekly measurement of body weight, rectal temperature and respiratory rate were made until they grow up to adult animals weighing around 250g.

Rectal temperature was measured at 11 a. m. by digital thermometer (Terumo) with insertion of thermistor probe into anal for 2 cm. Respiratory rate was counted by observation.

2. *Heat and cold load experiments*

Six adult pikas, put into six partitions separated by mesh wire in a glass desiccator

of which capacity was about 7 liters, were used for each experiment in order to measure total oxygen consumption. A Benedict-Roth type respirometer was connected via electrical pump to the desiccator to make closed circuit. A hundred per cent oxygen was filled in the circuit and flow rate of oxygen was 12 l/min. Expired gass was stirred with motor-drive fans attached in the desiccator, then passed through the canister of soda lime to return to the tank of respirometer for recirculation (for details see Kosaka et. al.,1984).

Oxygen consumption (Vo_2) was calculated as follows;

$$Vo_2 = \frac{\text{Total oxygen decrease in tank (ml/min)}}{\text{Total weights of 6 animals (kg)}} \times \text{STPD co-efficiency}$$

Experiments were made at normal (24.5-25°C), low (14-15°C), and high (29-29.5°C) ambient temperature in the artificial climate chamber.

RESULTS

1. *Developmental changes in body weight, rectal temperature and respiratory rate*

Fifteen pikas (6 males and 9 females) didn't show any significant changes in rectal temperature and respiratory rate from 3 weeks to 15 weeks old. Mean rectal temperature was 39.6°C and mean respiratory rate was 131c/min, with no statistical significance in sexual difference. (Table 1)

Table 1. Rectal Temprature, Respiratory Rate of Increase in Body Weight per Week in Pika (Whistle Rabbit) (Room Temperature 22°C)

sex & number	T. rect (°C)	RR (min^{-1})	Body weight (g/week)
total (n=15)	39.6±0.17	131±8	10.1±2.14
male pika (n=6)	39.6±0.14	131±10	11.4±2.41
female pika (n=9)	39.6±0.20	131±8	9.4±1.60

Each mean value among three groups is statistically not significant

Birth weight of pika was about 9 g and body weight gain per week was 10.1 g in average with steep growth curve 7 weeks old and became moderate afterwards.

2. *Oxygen consumption in warm and cold environment*

At 25°C of ambient temperature, Vo_2 was 19.8ml/min • kg and respiratory rate was 120-130c/min. At 15°C, Vo_2 was 32.0ml/min • kg and respiratory rate was decreased to 86-92c/min. In high ambient temperature (29°C), it was amazing that Vo_2 also showed increased value of 27.9ml/min • kg, with 200-230c/min of respiratory rate. In addition, pikas seemed exhausted when exposed to high ambient temperature.

DISCUSSION

Many biological data is accumulating in the studies on pika, however, physiological evidences of thermoregulatory mechanism of pika are still sparse. Even basic values of rectal temperature or respiratory rate were not clear. Respiratory rate of pika was 67±11 c/min and rectal temperature was 36.2±1.4°C under the anesthesia of Nembutal (Sawasaki and Nishida, 1983 reported in Japanese. Our data was taken unanesthetized pika, so these differences are possibly due to anesthetics. However we cannot say that these high rectal temperature and respiratory rate are normal value for *Ochotona*. Because pikas used in our experiments were laboratory animalsreared in constant room air, not native ones. So that our data should be noticed as nomal value of laboratory pika. The growth of pika was accordant with growth curve previously reported by Matsuzaki *et al.* (1980).

The oxygen consumption of pika is considerably of great value when they are exposed to low ambient temperature as well as moderate ambient temperature, which is greater than those of cold-acclimated rats (Hirata and Nagasaka, 1981; Griggio, 1982). However, rectal temperature of pika is much higher than that of such small animals of equal body weights; rather, which is close to rectal temperature of laboratory rabbits which have much less metabolic rate than pika (Kosaka and Simon, 1968; Morhardt and Morhardt, 1971; Kosaka *et al.*, 1984). It is inferred that high rectal temperature of pika would result from failure in heat dissipation or failure in attenuating the heat production. In heat load experiment, pikas were not able to diminish the output of heat production as well as not to increase in respiratory rate, only sprawling on the floor. Therefore it is concluded that their ability to live in cold climate is mainly achieved by increasing heat gain mechanism and they have little capability of attenuating metabolic activities. In addition, thermoregulatory peculiarity of pika would be preferable for defending transient low ambient temperature but not advantageous for cold-acclimation, or survival of species.

Nevertheless *Ochotona* is a true member of rabbit order (*Lagomorpha*), for it was proved to be related to the family *Leporidae* by the determination of amino acid squence of myoglobin (Dene *et al.*, 1982). According to them, the time of divergence of two families of *Lagomorpha* is considered to be between 32 and 38 million years (early in Oligocene era), however only one genus, *Ochotana* is surviving among family *Ochotonidae* while 23 genera were extinguished. Besides, *Leporidae* still contains 11 genera and do more than 20 fossil genera.

The fossils of *Leporidae* found in the strata of early Tertiary period are distributed only in Asia and America where contemporary pikas are confined to live. However, rabbits and hares are seen in native all over the world except Madagascal, Australia and New Zealand. And they probably became widely distributed from the end of Pleiocene to the beginning of the Ice Age (Fox, 1974). So that it is inferred that two families of *Lagomorpha* dwelled neighboring in the Eocene epoch then *Leporidae* started to imigrate

but *Ochotonidae* kept resident (or imigrated *Ochotonidae* were all extinct).

Disadvantages in thermoregulatory mechanism of pika is probably one of the reason why their genera were declined and they keep living in cold climate.

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ナキウサギ (Pika, *Ochotona rufescens rufescens*) の体温調節に関する研究

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始・漸新世時代からの生きた化石といわれるナキウサギ（pika）の実験動物化に注目が集まり，本邦では1974年以降，実中研で実験室内の継代繁殖に成功している．私共は pika の形態的特徴やその生体反応様式に興味をもち，特にその体温調節能について２，３の知見を得た．(1)室温 22°C 下の体温，呼吸数，体重増加は夫々，39.6°C，131c/min，10g/week を示し，(2)25°C，

60% の常温下での酸素消費量 19.8ml/min・kg，呼吸数 120～130c/min; 29.5°C，60% 暑熱下で夫々 27.9ml/min・kg，200～230c/min; 15°C の寒冷下では 32.0ml/min・kg，86～92c/min を示した．(3) pika の体温が家兎に比し高い理由は高い熱産生と低い熱放散に起因するが，運動量，耳介を含む皮膚体表面積，行動性体温調節能などの要因を統合すべきであろう．pika のこれら体温調節反応結果から体温調節機序および温度適応の問題点を年代的・地理的諸条件をふまえて考察した．

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