Subsection Zoology

Temperature Adaptation in the Snail Physa anatina[1]

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INTRODUCTION

It is well known that cold-blooded animals adapt to changes in their environmental temperature. Precht (1958) summarized various concepts on temperature adaptation in poikilotherms and divided the phenomenon into two types: 1) "Capacity adaptation" where adaptation occurs within the range of normal temperatures and 2) "Resistance adaptation" where adaptation is to extreme temperatures. He pointed out that the two adaptations are not always coupled together and that resistance adaptation is apparently more common than capacity adaptation. There is little data available in which both adaptations have been studied on the same species. The meager information on capacity and resistance adaptation in the Mollusca has been pointed out in a review by Segal (1961).

Near Montezuma, San Miguel county, New Mexico, the aquatic snail *Physa anatina* Say is found in the Gallinas River (summer temp. 26 C), in spring-fed, hot-water pools (until recently, summer temp. 38-40 C) along the bank of the river, and in the streamlets flowing from the pools to the river. From the pools to the river, the streamlets had a smooth temperature gradient of 40 C to 26 C. The environment provided an opportunity to study temperature adaptation of the snail in a natural or field condition. In the last year men modified the drainage from the hot-water pools. This caused the temperature of the pools to drop to approximately 30 C. In view of these changes it seems best to report the results of temperature adaptation studies that were being carried out on *P. anatina* before the temperature changes. Some of the determinations, unfortunately, are with limited numbers of snails.

The data presented in this paper concerns metabolic adjustment (as determined by following oxygen consumption) and lethal high temperature of snails from the river and pools. It contributes information on both capacity and resistance adaptation of *P. anatina*.

MATERIALS AND METHODS

Snails from the pools were collected and used on the same day. On occasion, snails from the river were maintained in an aquarium at 26 C for 2 or 3 days.

Standard Warburg apparatus and procedure were employed in determining oxygen consumption. Ten snails were used for each determination. At the end of the experiment the snails were analyzed for total nitrogen by the standard micro-Kjeldahl method. High lethal temperature was estimated by determining the highest temperature in which approximately 50% of a group of snails could remain for 1 hr and survive. This was determined in the following manner. Snails were placed in individual containers equilibrated to the experimental temperature. At the end of 1 hr each container and its snail was returned to the snail's normal environmental temperature. Snails were observed for signs of life 1 and 24 hr after they had been exposed to the experimental temperature. Any snail crawling or attached was recorded as alive.

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The results of the oxygen consumption measurements are presented in Table I. Oxygen consumption of the pool snails at 35 C was somewhat higher than that of the river snails measured at 25 C. However, when the river snails were placed in an environment of 35 C their oxygen consumption was increased sharply and exceeded that of the pool snails at 35 C by 1.10 $mm^3/mg\ N_2 \times 10/hr$. The oxygen consumption of pool snails was sharply reduced at a temperature of 25 C and was below that of the river snails by 0.96 $mm^3/mg\ N_2 \times 10/hr$.

If *P. anatina* in the pools had adapted to the higher temperature their metabolic rate at 35 C should be significantly lower than the metabolic rate of the river snails at 35 C. Further, the metabolic rate of the river snails at 25 C should be significantly higher than the metabolic rate of the pool snails at 25 C. The results in Table I suggest that adaptation had occurred. Significance of the observed differences between the means of

TABLE I. OXYGEN CONSUMPTION OF THE SNAIL *Physa anatina*

Snails' Environmental Temperature	Experimental Temperature	Oxygen Consumption ($mm^3\ O_2/mg\ N_2 \times 10/hr.$)	Q_{10}
River	25 C	2.44 ± 0.64 (5)	
(26 C)	35 C	4.30 ± 1.23 (7)	1.76
Pool	35 C	3.20 ± 0.89 (8)	
(38-40 C)	25 C	1.48 ± 0.55 (4)	2.16

The standard deviation for the oxygen consumption values were calculated as square root of s^2 (variance). The number in ( ) indicates the number of determinations. Ten snails were employed in each determination.

the pool and river snails' oxygen consumption at 25 C and 35 C was tested with the *t* test. The *t* value for the means at 25 C is 2.42. With 7 degrees of freedom, the difference in the two means is significant at the 0.05 level. The *t* value for the means at 35 C is 1.95. With 13 degrees of freedom, the difference in the two means is significant at the 0.05 level. The results indicate that *P. anatina* undergoes metabolic adaptation and suggests that it shows Precht's "capacity adaptation" in response to changes in its environmental temperature. Segal (1959) reported similar metabolic adaptation in the slug *Limax flavus* after adaptation under laboratory controlled conditions. "Capacity adaptation" to temperature has also been reported in the snail *Planorbis corneus* (Precht and Christopherson, 1965).

A limited number of determinations was carried out in an effort to establish the lethal high temperature for the river and pool snails. It is possible to obtain a useful estimate of lethal high temperature by determining the highest temperature in which the snail can remain for a given period of time and survive. In measurements with a group of 25 river snails 60% survived a 1-hr exposure to 41 C. In similar measurements with a group of 9 pool snails 66% survived a 1-hr exposure to 43 C. On several occasions snails from the river were placed in aquaria at 35 C and maintained for 1 to 2 weeks. The animals were alive and active when they were removed. The results of lethal high temperature suggest that *P. anatina* can develop a resistance to increased temperature. In other words the snail appears to show Precht's "resistance adaptation" in response to increases in the environmental temperature. Mews (1957) reported similar response in the terrestrial snail *Helix pomatia*. It is interesting that, with *P. anatina*, the lethal high temperature for the pool snails is only slightly above that for the river snails. Apparently the snails living in the pool are at a temperature very near their genetic limit.

In summary, *P. anatina* is capable of "capacity and resistance adaptation" to changes in its environmental temperature. The animal should be a very useful experimental animal for determination of the mechanism(s) of temperature adaptation in poikilotherms.

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