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Effect of body weight and acclimated temperature on the respiration physiology on seawater snail *Planaxis sulcatus*

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Abstract : This study was designed in Marine Sciences station (Aqaba) during the period September 2000 to October 2001 . The study of the effect of body weight on the metabolic rate revealed the presence of a proportional relationship between the metabolic and body weight and the presence of inverse relationship between the metabolic and body weigh.In snails acclimated to 10 ºC, 20 ºC, and 30 ºC, the Weight specific metabolic rate was influenced by both acclimation as well as experimental temperature. Thus, the oxygen consumption rate increased 1n 10 ºC acclimated snail from 44 µl O2. g^{-1} . hr^{-1} to 105 µl O2. g^{-1} . hr^{-1} As a result of increasing the experimental temperature from 10 ºC to 30. ºC In 20 and 30 ºC acclimated snail, and as a result of increasing the experimental temperature from 10 to 30, the weight specific oxygen consumption rates increased (20 ºC and 30 ºC) from 40 µl O2. g^{-1} . hr^{-1} to 88 and 35 to 85 µl O2. g^{-1} . hr^{-1} Respectively. Snails acclimated to 10 ºC ,20 ºC and 30 ºC showed Precht s type 3 normal the(partial) compensation in weight specific oxygen consumption rate , since at all experiment temperatures , the highest oxygen consumption rate was observed in 10 ºC Acclimated animals, whereas the lowest rate was observed in 30 ºC acclimated snails.

Key words: body weight , acclimated temperature , respiration physiology , ***Planaxis sulcatus***

Introduction

Planaxis sulcatus (Born, 1780) belong to the class Gastropoda, sub class Prosobranchia, order Mesogastropoda. Family planaxidae is one of common sea water snail species that is abundant in Gulf of Aqaba (1**)** The Gulf of Aqaba has an arid climate which is characterized by high temperature and evaporation rates (2), the sea shore of Aqaba, which is different into the sandy and rocky beach, is rich with several groups of animals like mollusca and Arthropod and various types of Nematode (3**)** . The geographic and littoral distribution of marine mollusks depends on their thermal tolerance limits (4).

Gastropods are the largest class of mollusks with about 30,000 marine species. The snails and slugs which are terrestrial and can breathe by their so called lung which is a modified mantle cavity**.** Snails are important from medical point of view since they act as intermediate hosts for many parasites to complete their life cycles (5**)**.

Metabolic rate in mollusks, as in other animals, is significantly influenced by the body size (or weight). Generally, the metabolic rate (Oxygen consumption per individual per unite of time) is higher in large animals as compared with small animals. This actually due to the increase in the total number of metabolizing cells in large individuals as compared with smaller number in small size individuals (6).

On other hand the weight specific metabolic rate in small size individuals is higher as compared will large one . this increase in the weight specific oxygen consumption rate in small individuals is attributed to increase in the proportion of tissue of low metabolic rate in large animal, as well as an increase in activities of enzymes and in mitochondrial number per volume (7).

Temperature is one of the environmental parameters, which exhibits distinct daily as well as seasonal variation. Temperature can also affect in addition to metabolism, the activity level and energy balance. The rates of most physiology and biochemical activities are affected by temperature. However, these physiology and biochemical activities do not rely on thermal environment since these activities are adjusted to compensate for variations is environment temperature(8).

such compensation is called acclimation if it is induced by a single environmental factor (such as temperature) in the laboratory and is called acclimation it induced by a group of environmental factors in nature (9**)**.The compensatory change in the rate of various physiological activities in response to the temperature changes called thermal acclimation (10).

Precht (1967) classified the phenomenon of thermal acclimation into two types:

Capacity acclimation which include the compensatory change that take place in various physiology activities in response to temperature change when they are measured at a normal temperature range.

Precht (1967) described five types of capacity acclimation. When warm acclimated poikiotherms are reaccelerated to lower temperature (i.e., during cold acclimation). The rate of a given physiology activity may increase (type 1-3 compensation). Or remain unchanged (type 4- compensation) or decrease (type 5- inverse compensation) when measured at certain intermediate temperatures. (Type 1-3 compensation (partial) is the most common type and of response among the piokilotherms(9)**.**

In intertidal mollusks and other poikilotherms, the physiological activities including the metabolic rate are greatly influenced both by experimental and acclimation temperature .The rate of respiration usually increases with increasing the experimental temperature until a maximum rate is attained. The temperature at which the animal exhibits a maximum rate of respiration is not the same fore all animals and depends on their previous thermal history (i.e., their acclimation or acclimation conditions) (11).

Normal compensation, in which the rate of respiration increases during cold acclimation, is the most common type of compensation in mollusks as well as in non – molluscan ectotherms.

Biochemical compensation in animal cells and tissues during thermal acclimation may be explained partly by temperature induced change in enzyme activity as suggested for several enzymes exhibiting compensatory changes in their catalytic activity (11)

The present work was undertaken to study some aspects of effect endogenous and exogenous factors , Effect of body weight and acclimated temperature on the respiration Physiology on seawater snail *Planaxis sulcatu*

Materials and methods

This work was carried out in Marine Sciences station (Aqaba). The snail used during the present investigation were collected from the Red Sea beach, the area within the marine Science station during the period September, 2000 to October, 2001 the temperature of the water was recorded during each collection. After collection, the animals were transferred in open plastic containers to the laboratory. The animals then distributed into open system glass aquaria (50 × 50 × 50 cm) filled with sea water and provided continuously with fresh sea water through an inlet opening and the excess water was overflowed through an outlet opening.

Prior to the experiments, the animals were acclimated to 10, 20 and 30 ºC for 28, 21, and 14 days, respectively. The temperature of one aquarium was maintained at 30 C by using a thermostatically controlled glass heater. The temperatures of the other two aquaria were maintained at 10 and 20 ºC by using cooling water bath and thermostatically controlled heater fixed at 10 and 20 ºC. the animals were continuously aerated by using high power aquaria pumps (ST-4000, Tainwan) and fed with brine shrimps. The animals were exposed to normal photoperiod under the laboratory.

The rate of oxygen consumption of the Gastropoda snail *Planaxis sulcatus* was measured using a plolrographic electrode (clark type) connected to an oxygen monitor (type YSI model 53) and chart recorder (type Graphic 1002Lioyed) . A closed transparent acrylic chamber (capacity of about 120 ml) provided with water jacket was used as a respiration chamber. The oxygen electrode was inserted into the chamber and connected to an oxygen monitor and chart recorder to record the change in the oxygen concentration in the respiration chamber. Before conducting the experiment, the unit was operated for about one hour to allow its stabilization and temperature equilibrium. The chamber was filled with filtered seawater and maintained at a constant temperature by setting the temperature knob of the cooling water bath that supplies the water jacket of the respiration chamber at a desired temperature.

After setting up the unit, one animal was placed inside the respiration chamber and after temperature re-equilibrium (about 30 minutes), the rate of oxygen consumption as indicated by changes in the oxygen concentration in the respiration chamber was recorded for 30 minutes. Finally, the rate of oxygen consumption was expressed as microliter of oxygen cosumed per individual per hour (µl.ind.hr) and the rate of weight specific oxygen consumption was expressed as microliter of oxygen consumed per gram of body weight per hour (µl.gm.hr).

To study the effect of body mass on the rate of metabolic rate, the rate of oxygen consumption of different size groups between 0.02 – 2.5 gs of 25 ºC acclimated snails was measured at 25 ºC , n =100

To study the effect of the acclimation temperature on weight specific rate, the rate of oxygen consumption in snails acclimated to 10 ºC, 20 ºC and 30 ºC were measured at experimental temperature 10 ºC, 20 ºC, and 30 ºC. the relation between the weight specific metabolic rate, the acclimation and experimental temperature was determined

Results and Discussion

The effect of body weight on the metabolic rate as well as the weight specific metabolic rate are shown in figure (1and 2).As the figures show the metabolic rate of *Planaxis sulcatus* acclimated to 25 ºC and measured at 25 ºC was curve linearly related to the body weight the relationship between the body weights (W) and metabolic rate (M) can be described as follows:

$$M = a W^b$$

Where : a and b are constant .

M is the metabolic rate (µl O2. g^{-1} . hr^{-1}).

W is the wet weight (mg)

The above equation can be described as follow:

$$\text{Log } M = \text{Log } a + b \text{ Log } W$$

Where : a = proportionality constant (Intercept) .

b = slope of linear regression line

After calculating the values for both a and b from the body weight- metabolic rate results and substituting them , the correlation between the metabolic rate and body weight can be expressed as follow :

$$\text{Log } M = -0.4687 + 2.2239 \text{ Log } W$$

Where : $r^2 = 0.2427$, $n = 100$

Low correlation was found between the metabolic rate and body weight ($r^2 = 0.2427$). Statistical analysis of the results showed that there were significant ($p<0.0005$)between the metabolic rates of different weight categories.

A negative correlation was found between the weight specific metabolic rate oxygen and body weight .This indicated that there was an inverse relationship between the metabolic rate and body weight (figure2) . Also, the results indicate that there is high negative correlation between the weight specific metabolic rate and body weight as indicated by its correlation coefficient ($r^2 = 0.7589$) furthermore, there was highly significant differences between the weight specific metabolic rate of difference weight categories ($p< 0.001$).

The presence of a low correlation coefficient between the metabolic rate and body weight may be due partly to the non uniform deposition of calcium carbonate and other shell elements (12)**.**

The mechanism responsible for a high weight specific metabolic rate in small individuals as compared with a large one is not yet fully understood . However, this increase in weight specific metabolic rate may be attributed partly to increases in the amount of tissues low metabolic rate such as connective and adipose tissues and shell components, that more increased weight specific metabolic rate in small individuals may be also interpreted or the bass increased oxidative enzyme activity, large mitochondrial number and size in small individuals (7) .

The high rate of weight specific oxygen consumption in small animals is probably a consequence of the greater metabolic requirements of small size animals for more energy production and its utilization in the anabolic activity during their growth (6).

The results of the experiments on the effect of measuring temperature 10, 20, and 30 ºC are shown in figure (3) and table (1). In all the acclimation group, the rate of oxygen consumption was increased with increasing the experimental temperature from 10 to 30 ºC. Thus, In 10 ºC acclimated snail, the rate of oxygen consumption was increased from 44 µl. g^{-1} . hr^{-1} to 105 µl. g^{-1} . hr^{-1} .as a result of increasing the experimental temperature from 10 to 30 ºC. Significant difference in the rate of oxygen consumption were observed between 10 and 20, 20 and 30, and 10 and 30 ºC ($p<0.05$). Due to increasing the experimental temperature from 10 to 30 ºC , the rate oxygen consumption of snail acclimated to 20 ºC and 30 ºC was increase from 40 µl O2. g^{-1} . hr^{-1} to 88 and 35 to 85 µl O2. g^{-1} . hr^{-1} , respectively .

In both acclimation groups, significant differences in the rate of oxygen consumption were found between the experimental 10 ºC and 20 ºC, 20 ºC and 30 ºC, and 10 ºC and 30 ºC ($p<0.05$) Both acclimation as well as the experimental temperature significantly influence the metabolic rate in aquatic ectotherms. Thus, in snail, the rates of weight specific oxygen consumption in 10 ºC, 20 ºC and 30ºC acclimated snails were increased with increasing the experimental temperature from 10 to 30ºC.

In snail, the weight specific metabolic rate of 10, 20 and 30ºC. Acclimated snails showed prechts type 3 compensation since at all the experimental temperatures. The highest rate of weight specific oxygen consumption was observed in 10ºC. Snails where as the lowest rate was observed in 30ºC. Acclimated snails.

Aquatic ectotherms remain active over a wide range of environmental temperature and are capable for metabolic compensation. Thus, cold acclimated animals exhibit a higher metabolic rate as compared to warm animals to provide the energy required for various physiological activities as low acclimation (habitat) temperatures (13)**.**

Compensatory changes in the animals tissues and cellular functions may be explained partly at the molecular level by temperature included a change in enzyme activity is strongly suggested by a large number of enzymes that exhibit normal compensatory changes. In the catalytic activity during thermal acclimation (14**)**,(12) .

In molluscs, several enzymes showed normal compensation type (2,3) during thermal acclimation such as pyruvate kainase of *M. edulis* (15) . The catalytic activities of these enzymes were enhanced by 1 to 2 fold during cold acclimation. These enzymes participate in various metabolic pathways such as kreb's cycle, Embden- Meyer Hoff pathway, pentose monophosphate shunt etc, (15).(1 6)

Partial or complete compensation in enzymes activities during thermal acclimation were exhibited by several enzymes extracted from various species of mollusks such as pyruvate kinase of *Helix promatia*

(10) and lactate dehydrogenase of *H. promatia* (17) , (18) , succinate dehydrogenase of *L. peregra* (19).

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Table 1 :Effect of acclimation temperature on the rate of weight specific oxygen consumption of *Planaxis sulcatus* at various experimental temperatures

Acclimation temperature°C	Experimental temperature°C	Mean	S.E.M.	N
10	10	44	2.132	10
	20	74	3.215	10
	30	105	1.542	10
20	10	40	1.648	10
	20	61	3.339	10
	30	88	2.527	10
30	10	35	1.896	10
	20	53	2.157	10
	30	85	3.012	10

S.E.M.= Standard Error of Mean N= Number of Experiments

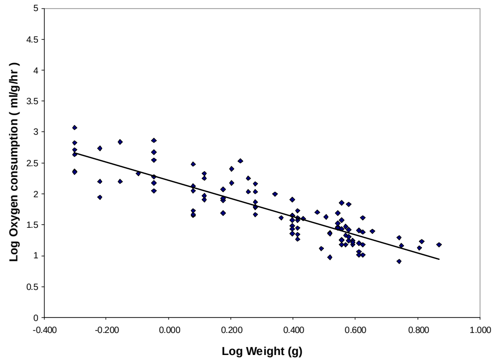

Fig.2 : Effect of body weight on weight specific rate of oxtgen consumption of the *Planaxis sulcatus*

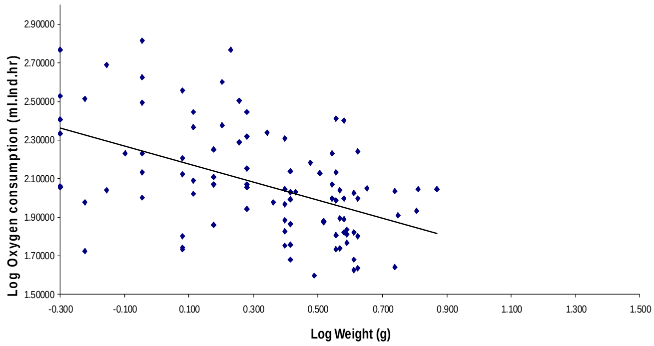

Fig.1 Effect of body weight on rate of oxygen consumption of the *Planaxis sulcatus* .

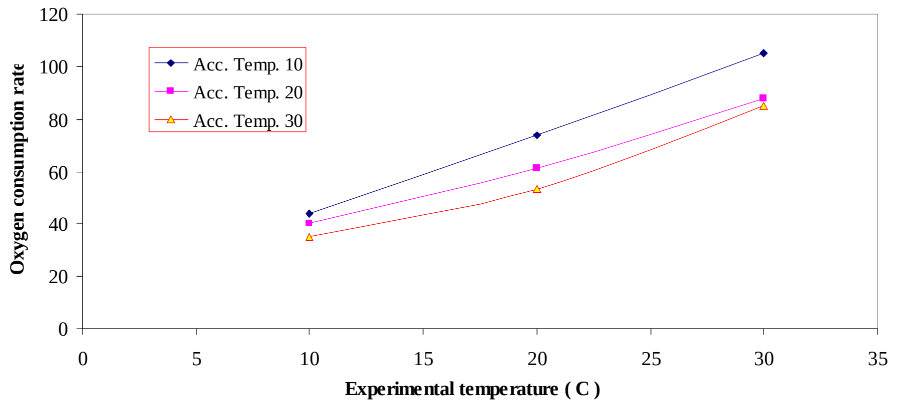

Fig3 :Effect of acclimation temprature on the rate of oxygen consumption of *Planaxis sulcatus* acclimated to 10, 20 and 30C

تأثير وزن الجسم و درجة حرارة التأقلم على فسيولوجيا التنفس في قوقع المياه المالحة (*Planaxis sulcatus*)

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الخلاصة

صممت هذه الدراسة في محطة العلوم البحرية في العقبة الأردن للفترة من أيلول إلى تشرين الأول 2001 لدراسة تأثير وزن الجسم ودرجة الحرارة على فسيولوجيا التنفس في قوقع المياه المالحة (بلاناكسيس سالكاتوس). وقد أظهرت النتائج وجود ارتباط بين وزن الجسم ومعدل استهلاك الأوكسجين المعتمد على الوزن حيث وجد أن هناك علاقة عكسية بين معدل استهلاك الأوكسجين المعتمد على الوزن و وزن الحيوان.

وكانت لدرجات حرارة التجربة والتأقلم تأثير واضح على معدل استهلاك الأوكسجين حيث ازداد معدل استهلاك الأوكسجين المعتمد على الوزن في الحيوانات المتأقلمة لدرجة حرارة 10 م° من 44 إلى105 مكل /غم / ساعة بسبب زيادة درجة حرارة التجربة من 10 إلى 30 م° كذلك ازداد معدل استهلاك الأوكسجين المعتمد على الوزن في الحيوانات المتأقلمة لدرجة حرارة 20 م° و30 م° من40 مكل /غم / ساعة إلى 88 مكل /غم / ساعة ومن 35 مكل /غم / ساعة إلى 85 مكل /غم / ساعة على التوالي .

أظهرت الحيوانات المتأقلمة لدرجات 10م , 20م و30م تعويضا في معدل استهلاك الأوكسجين المعتمد على الوزن من النوع الثالث للعالم برخت حيث كان معدل استهلاك الأوكسجين المعتمد على الوزن في الحيوانات المتأقلمة لدرجة حرارة 10 م° أعلى مقارنة بالحيوانات المتأقلمة لدرجة 30 م° وعند درجات القياس 10, 20 و30 م° .