OXYGEN CONSUMPTION AND METABOLIC RATE IN RELATION TO BODY SIZE IN THE INTERTIDAL GASTROPOD *TURBO INTERCOSTALIS* (MENKE)

by P. N. GANAPATI, F.N.A. *and* R. V. RAMASASTRY*, *Department of Zoology, Andhra University, Waltair*-530003

There have been many reports on the respiratory metabolism in relation to body size of several marine poikilotherms from arctic and temperate waters. In the present paper the results of the experiments conducted on the oxygen consumption and metabolic rate in relation to body size in the intertidal gastropod, *Turbo intercostalis* (Menke) are given. This animal is abundant on the rocky substrata of the Waltair coast at the region of the Mean Sea Level. The oxygen consumption measurements were made on 100 animals of different sizes ranging from 0.295 to 10.436 g wet weight using Winkler's method of determining the dissolved oxygen. The temperature and salinity were kept constant at 25°C and 30‰ respectively and the *p*H of the sea-water used did not vary much during different experiments.

The oxygen consumption of different size groups of *Turbo intercostalis* under constant temperature and salinity increased with the increase in body weight. The metabolic rate or weight specific oxygen consumption, i.e. O_2 uptake/g body weight/hr showed a decrease with the increasing body weight. Using the equation $Y=ax^b$; '*b*' was calculated by the statistical method of least squares and a value of 0.548 was obtained. The results are discussed with those of other authors.

INTRODUCTION

Many investigations have been carried out on the metabolic rates in relation to body size of several poikilotherms. Principal among them are the works of Weymouth *et al.* (1944), Zeuthen (1953, 1955), Prosser (1955) and Bertalanffy (1957). Zeuthen (1953) analysed the existing data in a number of marine poikilotherms and observed that in poikilotherms below a certain size the regression of metabolic rate with size was very slight, whereas, for larger animals this regression was greater. Bertalanffy (1957) concluded that in the various animal classes, three metabolic types, i.e. forms of dependence of metabolic rate on body size can be distinguished : proportionality of metabolic rate to surface area, or to weight, or one intermediate between surface and weight proportionality.

Recently we have carried out a number of experiments on the respiration of the gastropod, *Turbo intercostalis* which is very common in the intertidal region of the Waltair coast. The site from where the specimens were collected is an open coast and is not subjected to wide fluctuations of hydrographical conditions. In the present paper we have given an account of the metabolism in relation to the body size of *T. intercostalis*.

**Present address :* Department of Zoology, Sri. Y. N. College, Narsapur, Dt. West Godavari (A.P.).

Materials and Methods

Respiratory measurements were made using the standard Winkler's method (Welsh and Smith 1953). The respiratory chambers were designed after Jones Ericksen (1947). Wide mouthed pyrex bottles of 270 ml capacity were used as respiratory chambers. Experiments were carried out at a constant temperature of 25°±1°C. The sea-water used in the experiments was filtered through Whatman filter paper No. 42 and was air saturated (4.0 to 4.5 ml O_2/L). The salinity of the sea-water was adjusted to 30‰. The sea-water used during the different experiments had *p*H about 8, which did not vary much.

For smaller animals oxygen-consumption experiments were run for a period of five-six hours. A period of two hours was found to be sufficient for larger animals. In all the cases hourly oxygen consumption was calculated. The wet weight of the animal was determined to the nearest 10 mg immediately after the experimental period, by breaking open the shell carefully. The wet weight of the animal was taken into consideration. Experiments were performed on 100 animals of different sizes. All the animals used in the experiments were assorted into sixteen size groups depending on wet weight, and the oxygen consumption was expressed in relation to these size groups. Animals of the same body-weight were all averaged into one size group and only the average body-weight and the average hourly oxygen-consumption were considered for the presentation of the data and the statistical treatment.

Results

The oxygen-uptake and metabolic rate for the different sizes of *Turbo intercostalis* are presented in Table I. The average body-weight of the animals ranged from 0.295 to 10.436 g. The oxygen consumption varied from 0.266 to 2.084 ml O_2/hr, and the metabolic rate from 0.901 to 3.199 ml O_2/hr/g in the above size range. Oxygen-uptake increased with increasing body-weight in these animals. The increase in oxygen-consumption showed an exponential relationship with increasing body-weight. From the graph (Fig. 1) it can be seen that when the relative log oxygen-consumption was plotted against relative log body-weight, a positive linear correlation was obtained. The regression is of the form :

$$\text{Log. } O_2 = \text{Log. } 'a' + 'b'.\ \text{Log. } W \text{ (or } O_2 = a\ W^b) \qquad \ldots.(1)$$

where O_2 is the hourly oxygen consumption, W the wet weight of the soft parts, and a and b are the constants.

On the other hand the meatbolic rate, i.e., oxygen-uptake per unit body-weight per hour showed a decline with increasing body-weight and the plot of log metabolic rate on log body-weight showed a negative linear correlation (Fig. 2). The regression is of the form :

$$\text{Log. } O_2 - \text{Log. } W = \text{Log. } a + b.\ \text{Log. } W - \text{Log. } W \text{ (or } \frac{O_2}{W} = a\ W^{b-1}) \qquad ..(2)$$

Using the statistical method of least squares the regression value for the total oxygen consumption against body-weight was calculated and a value of 0.548 obtained,

which is the *b* value in eqn 1. The regression value for the weight specific oxygen consumption, i.e., O_2/hr/g is negative (–0.452) which is the *b*-1 value in the eqn 2.

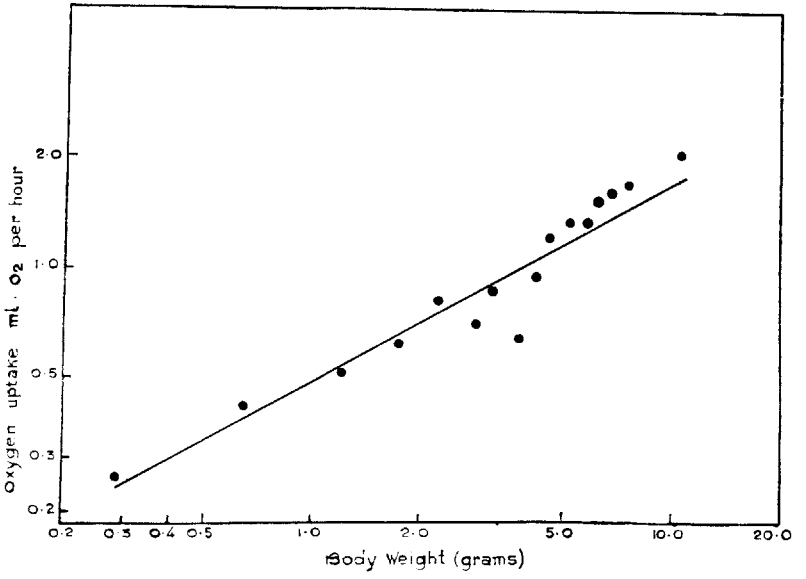

FIG. 1. Relationship between oxygen consumption and body weight in *Turbo intercostalis* (Double log plot)

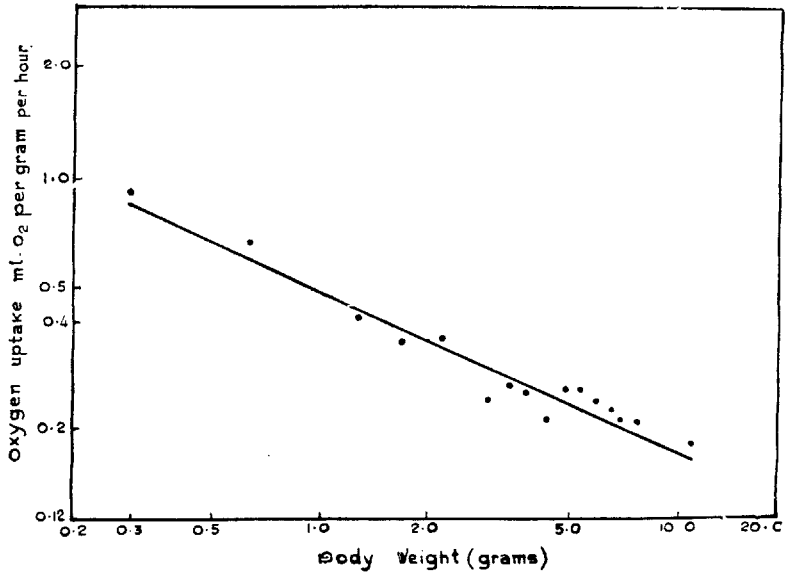

FIG. 2. Relationship between body weight and metabolic rate in *Turbo intercostalis* (Double log plot)

TABLE I

Oxygen uptake and metabolic rate in Turbo intercostalis

Body-weight (g) (*wet weight of soft parts*)	Oxygen uptake (*ml O_2/hr.*)	Metabolic rate (*ml O_2/hr/g*)
0·295	0·266	0·901
0·642	0·436	0·679
0·252	0·504	0·402
1·741	0·616	0·353
2·240	0·812	0·362
2·855	0·692	0·242
3·261	0·870	0·266
3·790	0·633	0·167
4·260	0·920	0·215
4·790	1·217	0·254
5·370	1·361	0·253
5·762	1·346	0·233
6·220	1·536	0·246
6·690	1·600	0·239
7·630	1·678	0·219
10·436	2·084	0·199

DISCUSSION

The results of experiments on the oxygen consumption and metabolic rate clearly show that the rate of oxygen uptake in *Turbo intercostalis* varies with the size of the animal. The total oxygen consumption in unit time is less in smaller animals, and more in larger ones. But, the metabolic rate or weight specific oxygen consumption, i.e., O_2/hr/g is comparatively more in smaller specimens. The total oxygen consumption increased with 0.548 power of body-weight and the weight specific oxygen consumption with –0.452 power.

Zeuthen (1947) while studying the body size relationship to oxygen consumption of marine poikliotherms gave a *b* value of 0.7 to gastropods. Although, not actual value of *b* was given by him, this value could be read from his graphs representing percentage decrease in metabolic rate and *e* values. It can be seen that the *b* value of 0.548 of *Turbo intercostalis* is lower than *b* (0.7) given by Zeuthen (1947) for gastropods. This may be due to the physiological variations between different species. A similar observation was made by Berg and Ockelmann (1959) who while studying the respiration of fresh water snails found that there is inter as well as intra specific variations in the *b* values.

It is seen that the value of 0.548 of *b* in this animal is different from 0.67 which is required by the 'surface law' of Bertalanffy (1967). The value of *b* in this animal is less than proportional to surface area and hence does not fit into any of the three categories of metabolic types suggested by Bertalanffy (1957). However,

Zeuthen (1955) has surmised that there are many more 'metabolic types' than the three suggested by Bertalanffy.

ACKNOWLEDGEMENTS

One of us (RVRS) is thankful to the C.S.I.R. for granting a Junior Research Fellowship, during the tenure of which the present work was carried out.

REFERENCES

Berg, K., and Ockelmann, K. W. (1959). The respiration of freshwater snails, *J. exp. Biol.*, **36**, 690–708.

Bertalanffy, L. Von. (1957). Quantitative laws in metabolism and growth. *Quart. Rev. Biol.*, **32**, 217–231.

Jones, Erichsen (1947*a*). The oxygen consumption of *Gastrosteus aculeatus* L. in toxic solutions. *J. exp. Biol.*, **23**, 298–311.

Prosser, C. L. (1955). Physiological variation in animals. *Biol. Rev.* **30**, 229–262.

Welsh, J. H., and Smith, R. I. (1953). Laboratory Exercises in Invertebrate Physiology. Burges Publishing Co. Minneapolis, pp. 126.

Weymouth, F. W., Crismon, V. E., Hall, H., Belding, S., and Field, J. (1944). Total and tissue respiration in relation to body weight : A comparison of the kelp crab with other crustacea and with mammals. *Physiol. Zool.*, **17**, 50–70.

Zeuthen, Erik. (1953). Oxygen uptake as related to body size in organisms. *Quart. Rev. Biol.*, **28**, 1–12.

———(1955). Respiration Comparative Physiology. *Ann. Rev. Physiol.*, **17**, 459–482.