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OXYGEN CONSUMPTION AND RESPIRATORY METABOLISM BY ORTHOMORPHA GRACILIS (KOCH)

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ABSTRACT

Measurements of respiration were made for different weight groups of Orthomorpha gracilis. The rate of oxygen uptake ($mm^3/O_2\ m^{h-1}$) increased as the size increased while the respiration rate (mm^3 / gm / h^{-1}) decreased. The Q10 value was estimated between 12°C and 24°C for O. gracilis and was found to have a value of 2.4. The best correlate of the rate of oxygen uptake was the " active surface " of the animal within the same species, but between different species, the best correlation was between the rate of oxygen uptake and the actual weight.

INTRODUCTION

Respiration is considered one of the most important

affecting such process.

MacFadyen (1961) and Phillipson (1963) has emphasised the importance of making metabolic measurements throughout the year. However Phillipson (1967), Byzova (1967), Gromysz-Kalkowska (1967, 70) and Wooten and Crawford (1974) concluded that the peak of respiratory rate, for the species they studied, coincided with the activity in the reproductive season, for each species. Similarly oxygen consumption closely followed fluctuations in seasonal temperatures (Kayed, 1977).

In this endeavour the author studied the correlation between oxygen consumption and size of the animal, expressed by its weight as well as the processes of respiration in both sexes as a function of environmental temperature and varying activity of the animals.

MATERIAL AND METHODS

Millipedes were collected by hand from the botanical green houses of the Faculty of Science in which the winter temperature ranged between 20 - 26°C. The collected adult males and females were kept at room temperature in glass terraria provided with soil and one species of leaf litter Ficus sycamore as a preferred diet for O. gracilis (Khirallah & Kayed (1971);Kheirallah

(1978). Oxygen consumption was determined by the micro-respirometer method in a Warburg apparatus.

Experiments were run for three hours during which readings were recorded at 15 minutes intervals except at 10°C where Oxygen consumption was recorded every 30 minutes.

In each experiment, the test animals were left for 30 minutes to adapt themselves to the experimental temperature.Oxygen consumption, throughout the three hours was considered against a Zero temperature and pressure of 760 mmHg.

The millipedes were weighed immediately before the experiment and subdivided into three groups : 30 - 40 mg, 50 - 60 mg and 70 - 80 mg. In order to eliminate the time of day effect on the activity of the animals, Kayed,(1977), in the oxygen consumption, all the experiments were carried out before noon and during the same hours.Measurements were taken for each animal separately in order to avoid the additional stimuli which may occur during group testing of these animals and which may affect the experimental results.

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RESULTS

The complete data on oxygen consumption using various stadia of Orthomorpha gracilis are listed in Table 1.1-1.4. Oxygen consumption was determined in 800 specimens where body weight ranged between 30 and 94 mg, with the average weight of 58 within the range of experimental temperature was almost identical except those kept at 14.5°C the average body weight was 69.4 mg.

Table 1 shows that respiration intensity increased with rise of temperature. This is evident in the mean values for oxygen consumption at the respective temperature as well as in the average values for oxygen consumption per gram of body weight at the same temperature. Statistical analysis reveals that the coefficient of correlation (e,) calculated for oxygen uptake with respect to the total body weight (O2 : W) approaches unity at all temperature levels. Hence, oxygen consumption is a function of the body size. Furthermore, the correlation coefficient (r^2) for oxygen uptake per gram of body weight and the total weight of animals gave negative and almost similar results at temperature 14.5°C and 28°C. This indicates interdependence between these two parameters. It follows that oxygen consumption per gm of body weight decreases with increasing body size.

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Oxygen consumption per unit of weight and its correlation with temperature was calculated from the regression line (Table 2). In all the weight classes of test animals the oxygen consumption increased with increasing temperature. However, at the same temperature, the metabolic activities in larger animals are lower than in smaller animals.

Differences in oxygen consumption at different temperature gradiants are recorded by the coefficient Q 10 (Table 3), that was highest at the lowest temperature.

Differences in respiration metabolism frequently occur between sexes of the given species. These differences are correlated with the physiological condition of the animals and the external factors. The male and female O. gracilis belonging to two activity groups, inactive and active are listed in Table 4, oxygen consumption for these animal was measured at temperatures 10 to 28°C.

The recorded data suggested that females require less oxygen than males, though this differences has turned out statistically non-significant.

DISCUSSION

Animal activity is determined by the consumption of oxygen. However, muscular activity and function of the

internal organs of arthropods are difficult to asses. Under experimental conditions of small measuring vessels, it is not easy to observe the degree of activity of the animals confined to a limited area. Therefore, not all the activity groups were estimated perfectly. This may account for the statistically non significant differences in oxygen consumption.

The positive correlation between the level of oxygen consumption and body size and negative correlation between the level of oxygen consumption per unit weight and body size in o. gracilis confirms to the regular pattern of metabolic processes established for various poikilothermal animals (Zeuthen, 1955; Prosser and Brown, 1961).

Interdependence of the regression coefficients and temperature changes has been revealed in various taxonomic groups of animals whose temperature varies with that of the surroundings. (Wooten and Crawford, 1974; Kayed 1977; Gromysz-Kalkowska et al., 1985; in Diploods). In spite of the temperature induced variability, the value of regression coefficient is a characteristic feature of the species. Bertalnffy and Krywienczyk (1953); Kayed (1977) and Boccardo et al., (1986) experimentally established a relationship between respiration and the body surface

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and live weight in several species of poikilothermal animals namely : metabolism is directly proportional to the body surface.

Since the values of b. ranged from 0.66 to 1.0 indicating an intermediate type then it should be assumed that the respiratory metabolism of O. gracilis is dependent on both the external surface of the body and on its weight (Table 1).

The increase of O_2 consumption with increasing temperature is a common phenomenon. However, it is neither uniform within individual temperature gradient nor similar in every weight group of animals (Table 2). A relatively uniform respiration metabolism was evident within temperature 10° - 19°C. This is probably due to the response of the test animals to a typical environmental temperature lower than the required optimum temperature. At this temperature the millipedes are less active and therefore their oxygen requirements are more uniform.

The activity of the animals increased with increasing the temperature from 19° - 22°C, hence the greater differences in oxygen consumption of the tested groups are related to the lower temperature. The temperature [illegible] from 22° to 25°C characterized the stability of the respiratory metabolism of the population of millipedes.

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The latter interval seems optimal for the metabolism of Orthomorpha gracilis. Many poikilothermal species exhibit a certain degree of independence in their metabolic processes of temperature (Pentado, 1985).

In general, this phenomenon should be regarded as compensation symptom rather than a missing sensitivity to environmental temperature increase in the animals. In O. gracilis the rise of temperature from 22 - 25°C is compensated by a reduced activity of the individuals at 25°C when compared with that at 22°C. When the temperature reached 28°C the millipedes activity was reduced and the oxygen consumption was notabily diverged in some animals (Table 3).

Adaptation of respiration O. gracilis to the temperature range 22-25°C is further evidenced by a considerable decrease in the value of Q 10 (Table 3). A similar result was found by Vernberg (1954) during his study of crabs Uca Minax and Uca pugax. Armitage (1962) revealed a lower oxygen consumption at a temperature of 2-6°C in Orchomonella chilensis. Orthomorpha gracilis lives under typical environmental conditions exclusively in the tropics. As regards glass-houses of temperature climate it dwells in those with sufficiently high temperature ranging, in the winter, between 21° and 26°C.

REFERENCES

ARMITAGE, K. (1962) : Temperature and Oxygen [illegible] of Orchomonella chilensis (Hell[illegible], [illegible] Gammaroidea).
Biol. Bull. 123 : 225 - 232.

BERTALANFFY,L., KRYWIENCZYK, J. (1953) : The [illegible]rface rule in crustaceans.
Amer . Nat., 87 : 107 - 110.

BOCCARDO, L., PENTADO, C.H.S. (1986) : Oxygen consumption in Gymnostreptus Olivaceus, 1944 (Diplopoda, Spirostreptide) in relation to size and sex.
Brazil. J. Med. Biol. Res., 19 : 4 - [illegible]

BYZOVA, J.B. (1967) : Respiratory metabolism [illegible] millipedes (Diplopida).
Rev. Ecol. Biol. Soil. 4 611 - 624.

GROMYSZ-KALKOWSKA, K. (1967) : Minimum, maximum and preferential temperature in Orthomorpha gracilis
C.L. Koch Folia. Biol. 15, 101 - 11[illegible].

GROMSZ-KALKOWSKA, K. (1970) : Thermal behaviour of variously acclimatized individuals of [illegible] complanatus L. (Diplopoda) in a [illegible]ature gradient. Folia. Biol. 18, 205 [illegible]

GROMYSZ-KALKOWSKA, K. : TRACZ, H. & SZUB[illegible] F. (1985) Metabolic rate in relation to body weight food kind and time of day [illegible]ulus saltulosus (L.) Fol. Soc [illegible] Lublinensis

KAYED, A.N. (1977) : Bioenergetics of Ophyiulus pilosus (Newport) with notes on other millipedes. Ph.D. Thesis. Manchester University U.K.

KHEIRALLAH, A.M. (1978) : The consumption and utilization of two different species of leaf litter by a laboratory population of Orthomorpha gracilis (Diplopada : Polydesmoideas. Ent. exp. & Appl. Holand, 23 : 14 - 19.

KHEIRALLAH, A.M. AND KAYED, A.N. (1971) : Food and feeding habits of the hothouse millipede Orthomorpha gracilis (C.L. Koch). Alex. Bull. Fac. Sc., 11 : 275 - 285.

MACFADYEN, A. (1961) : Metabolism of soil invertebrates in relation to soil fertility. Ann. Appl. Biol. 49. 216 - 219.

PENTEADO, C.H.S. (1985) : Thermal tolerance and respiratory metabolism in the millipede Rhinocricus padberghi (Spirobolida) acclimated to different temperature. Brazil. J. Med. Biol. Res., 18 : 5-6.

PHILLIPSON, J. (1963) : The use of respiratory data in estimating annual respiratory metabolism, with particular reference to Leiolumum rotundum (Latr) (Phalangiida). Oikos, 14, 212 - 223.

[illegible] (1967) : Studies on the bioenergetics of [illegible]

In, Secondary Productivity of Terrestrial Ecosystems (Principles Methods), ed. K. Petrusewicz, Warszawakrakow, pp. 674 - 683.

PROSSER, C.L. and BROWN, F.A. (1961) : Comparative animal physiology. 2nd edn. Saunders, Philadelphia and London.

VERNBERG, F. (1959) : Studies on the physiological variation between tropical and temperature zone fidder crabs of the genus UCa. II Oxygen Consumption of whole organisms.
Biol. Bull., 117 : 163 - 184.

WOOTEN, R.C. and CRAFORD, D.S. (1974) :
Respiratory metabolism of the desert millipede Orthoporus ornatus (Girrard) (Diplopoda).
Oecologia (Berl), 20, 231 - 236.

ZEUTHEN, E. (1955) : Comparative physiology of respiration
Ann. Rev. Physiol. 17, 459 - 482.

Table 1: Oxygen consumption in Orthomorpha gracilis at various temperatures.

Temperature in °C	Live weight in mg Means and limits X	Means and limits of O_2 uptake in $mm^3/hr/animal$	Means and limits of uptake of O_2 per unit wt in $mm^3/hr/g$	Coefficients b	o.	b-1	r_1	r_2
10.0	30.1-55.1-93.8 (130)	1.17-2.28-4.27	25.8-41.5-54.3	0.90	0.08	-0.12	0.98	-0.56
14.5	32.3-59.4-92.1 (120)	2.1-3.9-7.2	45.0-72.2-103.2	0.76	0.03	-0.24	0.98	-0.94
19.0	32.7-54.9-89.2 (122)	2.5-5.7-12.2	65.4-103.4-157.2	0.94	0.10	-0.04	0.97	-0.17
22.0	33.2-56.4-87.6 (122)	3.8-8.0-14.8	80.6-143.6-228.0	0.87	0.14	-0.13	0.95	-0.45
25.0	31.5-55.7-92.7 (122)	4.6-8.4-15.5	107.4-147.3-228.0	0.85	0.07	-0.15	0.98	-0.90
28.0	29.4-54.9-89.5 (122)	4.3-9.7-19.3	103.8-181.0-267.1	0.79	0.1	-0.18	0.98	-0.87

The figures in brackets represent the number of replicates used.

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Table 2: Oxygen consumption (O_2 mm³/hr/gm) independence of the weight of O. gracilis.

Means of live body weight mg	Temperature °C					
	10.0	14.5	19.0	22.0	25.0	28.0
35	43.8	84.9	104.9	152.9	158.1	196.4
45	42.5	80.8	103.9	147.9	142.3	187.6
55	41.5	76.3	103.2	144.0	147.8	181.3
65	40.7	73.4	102.6	141.9	144.9	175.5
75	39.7	70.9	102.1	138.3	141.1	171.1

Table 3: Q 10 of the oxygen consumption in Orthomonas gracilis.

Live body weight in mg	Temperature in °C				
	10.0-14.5	14.5-19.0	19.0-22.0	22.0-25.0	25.0-28.0
35	4.3	1.6	3.5	1.1	2.1
45	4.2	1.7	3.2	1.0	2.0
55	3.7	1.9	3.0	1.1	1.9
65	3.7	2.1	2.9	1.1	1.9
75	3.6	2.3	2.7	1.1	1.9

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Table 4: Oxygen consumption in Orthomorpha gracilis in relation to sex and activity.

Temperature in °C	State of Activity			
	♂ Inactive	♀	♂ Active	♀
	O_2 mm³/hr/g	O_2 mm³/hr/gm	O_2 mm³/hr/gm	O_2 mm³/hr/gm
10	(17) 37.9	(24) 36.5	(2) 51.6	(15) 45.6
14.5	(5) 79.3	(22) 62.3	(10) 92.5	(14) 80.9
19.0	(10) 94.9	(20) 91.0	(11)122.1	(14)110.3
22.0	(13) 119.9	(21)132.9	(27)177.9	(8)142.7
25.0	(11) 152.8	(35)139.5	(7) 198.6	(7)176.2
28.0	(34) 186.1	(40)179.5	(4) 179.5	(3)182.6

The figures in brackets represent the number of replicates used.

استهلاك الاكسجين والتحول الغذائى التنفسى بواسطة اوتورفا جراسيلس

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تم عمل قياسات التنفس لمجموعات مختلفة من أرتومورفا جراسيلس وقد وجد ان معدل استهلاك الاكسجين يزاد كلما ازداد الحجم ٠ بينما معدل التنفس يقل٠ وقيمة ١٠ قد تدربت عند درجتى ٦٢ ، ٢٤ لحيوان الاوتومورفا ـ جراسيلس ووجد تساوى ٠٢ر٤ وقد وجد أن أنضل علاقة بين معدل استهلاك الاكسجين هى السطح النشط للحيوان من نفس النوع ولكن بين الانواع المختلفة بأن العلاقة الوحيده تكون بين معدل استهلاك الاكسجين والوزن الحقيقى للحيوان٠