EXPERIMENTAL INVESTIGATION OF THE RESPIRATION OF NYMPHS OF PALINGENIA LONGICAUDA OLIV. (EPHEMEROPTERA)

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Abstract

The oxygen consumption of the nymphs of *Palingenia longicauda* OLIV. is influenced by temperature and light, as depended upon their age. The oxygen requirement calculated according to the body weight is higher in case of younger nymphs than in that of older ones. The older nymphs, however, increase their oxygen requirement in a high degree before their transformation. After a transitory inhibition, the oxygen uptake is stimulated by light similarly as by temperature.

The investigations of respiration have a very great importance in understanding the ecology of the insects living in water. That is shown also by the rather comprehensive literature already treating of this problem. The mayflies have, however, been pushed fairly into the background in this respect. Our experimental animal, *Palingenia longicauda* OLIV. belongs to this group, as well. Its limited geographical distribution, the long development of its nymphs, its peculiar ecological conditions, and the very short life of the imago are raising several problems to be responded. For understanding these we can get a great help by recognizing their respiration. Taking into consideration the entirely special demands of this organism, we may reckon upon drawing a conclusion by means of them concerning the physical state, pollution of water. That is to say, the nymphs of *Palingenia longicauda* OLIV. as bio-indicators may characterize the pure state of natural waters. With regard to that, we investigated seasonally (September—October) the respiration of the nymphs of this organism, as induced by various factors (light, temperature).

Materials and Methods

The nymphs of different age, development and weight of *Palingenia longicauda* OLIV. were collected partly from the reaches of the Tisza, partly from those of the Maros at Szeged (between September 11th and October 30th 1970). They were investigated partly immediately, partly after a laboratory observation for a longer or shorter time.

The oxygen consumption of animals has been determined by Warburg's manometric process. There was put one animal of known weight in each 5 ml fluid of the manometer vessels, and 0,2 ml 20 p. c. KOH was measured to it for fixing the carbon dioxide produced at the respiration. The vibration speed was 77/sec. Our experimental results have been established from the data of 24 parallel measurements.

At our experiments we have endeavoured to ensure that they should reflect the natural states, standing very close to them. Therefore examining the oxygen consumption of the animals put in

distilled water, we have measured, as a control, also the respiration of some animals in filtered Tisza water (for that purpose we had taken water from a site where there was no sewerage in a distance of 100—150 m). At evaluating the factors having influence on the intensity of respiration, there have always served the quantities of the oxygen consumption calculated for 1 gr live weight (Q_{02}) as a basis for comparison.

Results and their discussion

It is a known fact that the intensity of respiration is influenced by external and internal factors and that among them the latter ones are of higher importance. For being able to understand their essence, we may not separate the two ones from each other. That was taken into consideration as we have reported on the effect of some physical factors modifying the intensity of respiration.

First we wanted to clarify, of what degree the difference is between the respirations in natural water (river water) and in distilled water, and in which degree the water influx could be regulated, resp. tolerated by the nymphs investigated in an ionless milieu. It has appeared in the course of the comparison of the two parallel investigations that the values measured in distilled water were in any case higher (Table 1), showing that a major change in the osmotic relations could not be tolerated by the nymphs. The organism hasn't any regulative system for impeding the influx of pure (ionless) water. A fast permeation of water is overstraining the energy system of organism, increasing for a while its metabolism, its oxygen requirement but leading at last to the destruction of the organism.

Table 1. *Oxygen consumption of the nymphs of Palingenia longicauda* OLIV. *of different weights*

Body weight of nymphs in mg	Q_{O_2}	
	Filtered river water	Distilled water
230	2.79	3.52
280	2.07	3.24
620	1.90	2.09
630	1.82	2.49

As known, the nymphs of *Palingenia longicauda* OLIV. live in dark ducts made by themselves. It may be supposed that they are adapted to the ecological conditions like these to a great extent, and their photosensitivity changed, as well, considerably. As photosensitivity can be concluded from the behaviour in the dark and by daylight — in the present case from the change in the intensity of respiration — we have measured the oxygen consumption of nymphs first in the dark and then by daylight. For studying the effect of daylight, we have illuminated the nymphs with a light of 90 lux.

It is obvious from the data of the Table that, at measuring the oxygen consumption, we have also taken into consideration to have animals in the vessels with a proportionately growing weight. It turned out that the values of the oxygen consumption for an hour of the nymphs were growing till a ceratin weight group and then, after a strong decrease, they begin increasing again. The phenomenon may be connected with the different age of life of the nymphs. This conection is in case of *Palingenia longicauda* OLIV. of linear character.

It is shown by several ecological investigations that there is a connection between the development of animals, food, etc. and the oxygen consumption (EDWARDS 1937, FOX et al. 1937, ALLEN W. KNIGHT and ARDEN R. GAUTIN 1966, ERIKSEN

Table 2. *Values of the oxygen consumption (20 °C) of the nymphs of Palingenia longicauda* OLIV. *of different weight in the dark and by light (90 lux)*

Body weight of nymphs in mg	Values measured in the dark		Values measured by light	
	O_2 consumption in 1 hour in ml	Q_{O_2}	O_2 consumption in 1 hour in ml	Q_{O_2}
155	—	—	48.2	3.41
200—300	44.3	1.70	62.8	2.57
300—400	68.7	1.94	62.7	1.96
400—500	131.2	2.70	64.8	1.40
500—600	85.7	1.67	71.1	1.30
600—700	115.0	1.82	90.3	1.68
700—800	—	—	132.0	1.85

1968, REICHLE 1968, THEODORE et al. 1968). Genetic determination, development and sexual maturity have, anyway, some importance, too. It can be seen from our results, as well, that the metabolism of younger animals is more active than that of older ones, and that before sexual maturity, resp. during it, the respiration of nymphs is rocketing.

As a result of light, the Q_{O_2}-values change in inverse ratio to the decrease in weight of nymphs, that is to say they decrease but that is valid only till about 600 mg body weight. Above that weight group, the Q_{O_2} increases again, and the data obtained don't show any major difference from those measured in the dark.

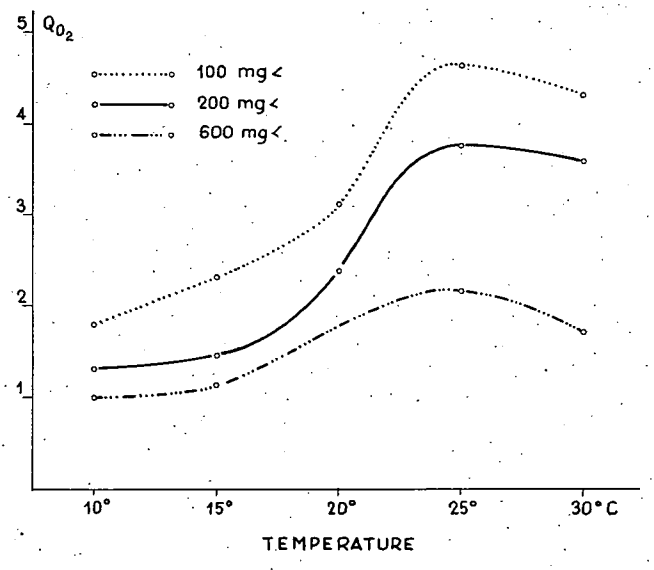

Fig. 1. Oxygen consumption of the nymphs of *Palingenia longicauda* OLIV., taken as a function of temperature.

It can be established by comparing the values of Table 2, that the O_2 consumption of the nymphs of *Palingenia longicauda* OLIV. is inhibited by the light in the ratio of the increase in body weight till the state of sexual maturity; then, however, just the other way round, the light is exerting a stimulatory effect.

It is known that the animals don't respond to the light in the same way. There is elicited some light reaction at animals adapted to the daylight and another at those accustomed to the dark. Thus, for instance, at the *Tetrahymena pyriformis* GL. accustomed to the normal light the respiration is stimulated by being illuminated (BICZÓK 1968). We can draw the conclusion from similar results (EDWARDS 1937, ISTENIČ 1963), as well as from our own measurement, that the nymph of *Palingenia longicauda* OLIV. has for a long time adapted itself well to living in the dark. In the

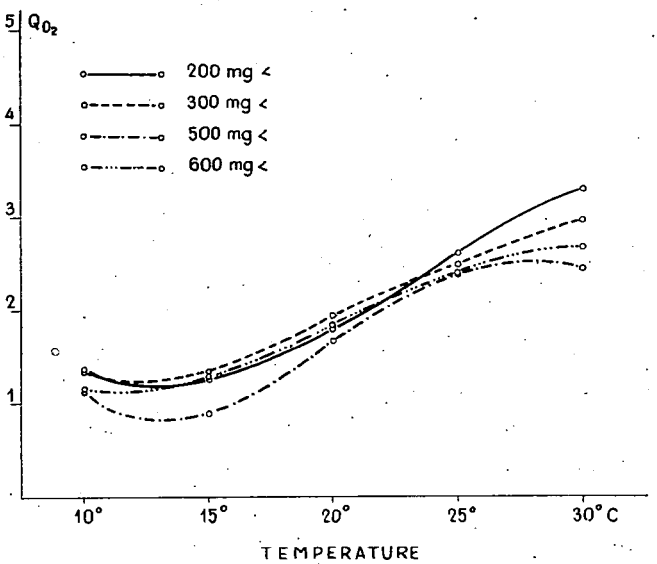

Fig. 2. Thermo- and photo-induced (90 lux) oxygen consumption of the nymphs of *Palingenia longicauda* OLIV. of different weight.

final period of their development, however, there comes into prominence a light reaction that may obviously be characteristic of the imagos living in natural light. Here it must be noticed, too, that the motion of nymphs is more and more increasing in that time, and there may be observed a striving from the concealed course of life after a less or not at all concealed course.

Apart from the light, we have taken into consideration the effect of heat, as well. As kown, the metabolism of an organism is increased by temperature (EDWARDS 1937, FOX et al. 1937, BERG et al. 1962, ISTENIČ 1963). That is, of course, valid only till certain temperature value above which heat has already a damaging, devastating effect.

In case of the nymphs of *Palingenia longicauda* OLIV. the change in metabolism caused by the increasing temperature can be determined from the values of the graph of oxygen consumption recorded in Fig. 1. As was to be expected, the connection is of direct proportion, the oxygen consumption growing in the ratio of raising the temperature. That increase goes on till about 30 °C. After that a slow decrease can be observed.

It seemed to be interesting to investigate the common effect of two factors, namely that of an increase in light and temperature (Fig. 2). Also the curves showing the results have a single maximum, and it is at 25 °C.

The difference of the two graphs (Figs. 1 and 2) is decided. It may be recognized well that in case of a common effect of both factors the values of oxygen consumption are always higher as if the factors had exerted separate effects. In addition, the maximum presents itself about 5 °C earlier.

Summary

Values of oxygen consumption of the nymphs of *Palingenia longicauda* OLIV. have been investigated under standing and changing temperature and light conditions. We have established that the metabolism of younger nymphs, under identical conditions, is more active than that of older ones, except the last nymph state where we have observed an increased oxygen consumption before the formation of imago.

The oxygen uptake was initially inhibited, later on stimulated by light. The temperature was of stimulating effect on any nymphs. Above 30 °C, metabolism was decreasing owing to the photo-lesion.

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