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# EFFECTS OF PHOTOPERIOD AND SIZE ON THE OXYGEN CONSUMPTION OF THE DUSKY SALAMANDER, *DESMOGNATHUS FUSCUS*[1]

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ABSTRACT

Three experimental groups of salamanders were acclimated in environmental chambers for 25 days at 10°C to photoperiods of 0 hours, 8 hours, and 16 hours. No significant differences were found in oxygen consumption between males in intergroup comparisons or between the sexes in intragroup comparisons. Females in the 16-hour and 0-hour groups did show significant differences in oxygen consumption. A strong positive correlation was found to exist between oxygen consumption and body weight in all groups.

## INTRODUCTION

Physiological cycles are common in temperate vertebrates; they prepare the animals for growth and reproduction during the most favorable seasons. The annual photoperiod cycle provides a reliable environmental stimulus for these metabolic changes in many organisms. In spite of a rapidly growing knowledge about the effects of photoperiod, little information concerning the regulatory effect of day length on amphibian metabolic cycles is available.

In several studies, oxygen consumption in poikilotherms has been found to vary seasonally. Wells (1935), using the Pacific killifish, found maximum oxygen consumption to occur in the summer. Vernberg (1952) reported maximum oxygen consumption in June for the salamanders *Eurycea bislineata* and *Plethodon cinereus*. A summary of observations from 1849 to 1954 on frog metabolism by Fromm and Johnson (1955) shows that maximum values for oxygen consumption of frogs occur generally during the spring. The possible regulatory role of photoperiod in controlling the seasonal differences in metabolism was not considered in these studies.

Whitford and Hutchison (1965), in the only study of the effects of photoperiod on the oxygen consumption of salamanders, acclimated *Ambystoma maculatum* to

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0 hours, 8 hours, and 16 hours of light at 15°C. Their dark-acclimated group had significantly higher and more variable rates of pulmonary and cutaneous gas exchange than the other two groups. The 16-hour photoperiod group had a significantly higher rate of oxygen consumption than the 8-hour group. As they suggested, the higher metabolism of the animals acclimated to complete darkness may have resulted from a stimulatory effect of being tested in the light. Cole and Allison (1929) showed that light will stimulate the oxygen consumption of frogs that have been kept in the dark.

The purpose of the present study was to determine the effect of photoperiod on the oxygen consumption of a plethodontid salamander, *Desmognathus fuscus fuscus*, and to determine if illumination during testing increases the oxygen consumption of dark-acclimated salamanders. The relationship between oxygen consumption and body weight was also considered.

## MATERIALS AND METHODS

The dusky salamander, *Desmognathus fuscus fuscus*, commonly occurs in Ohio along the banks of gorge-bottom streams under rocks, rotting logs, bark, and wet leaf litter. The breeding season is in the spring; eggs are deposited in moist nesting sites from late spring to late summer.

The salamanders used in this study were collected on 27 April 1966, in Beaver Creek State Park, Columbiana County, Ohio. The following day they were divided into three groups of 47 to 54 individuals each and placed in environmental chambers maintained at 10° ± 1° C. Photoperiods were centered at noon and were controlled by time clocks connected to six 40-watt fluorescent bulbs mounted in the doors of the chambers. One chamber housed the 16-hour photoperiod group (16 L) and the 0-hour photoperiod group (0 L). The latter was established by covering fingerbowls with aluminum foil. The 8-hour photoperiod group (8 L) was housed in another identical chamber. The animals were not fed during the period of acclimation (20–25 days). No salamanders died during the testing and all animals appeared to be in good health at the time measurements were made.

Oxygen consumption was determined in a Scholander micro-volumetric respirometer (Scholander *et al.*, 1952). The apparatus consisted of ten individual constant-volume respirometers which were placed in a constant-temperature water bath.

Beginning with the twentieth day of acclimation, ten individuals from each group were tested daily. The sequence in which the groups were tested was altered daily to compensate for the possible daily variation in oxygen consumption which has been observed in newts (Brown *et al.*, 1955). The salamanders to be tested were removed from the chambers one hour before testing to allow for temperature equilibration. All measurements of oxygen consumption were determined at 25°C between 1800 and 0300 EST. The 16 L and 8 L groups were tested in the light. The 0 L group was tested in the dark. Oxygen consumption is reported as cubic millimeters of oxygen at STP.

## RESULTS AND DISCUSSION

### *Relationship of Oxygen Consumption to Body Weight*

Figure 1 shows a double logarithmic scatter diagram of oxygen consumption per hour versus body weight for the 8 L group. A significant positive correlation between oxygen consumption and body weight was found in this group ($r = 0.93$) and in the 0 L and 16 L groups ($r = 0.76$ and 0.88; $P < 0.05$). A comparison of the regression coefficients did not yield significant differences, although there was a trend of increasing slope with increased photoperiod, with regression coefficients of 0.80, 0.82, and 0.85 for the 0 L, 8 L, and 16 L groups, respectively. These values compare favorably to those of Tashian and Ray (1957), who obtained regression coefficients of 0.83 and 0.86, respectively, for five species of tropical anurans determined at 25° and 10°C.

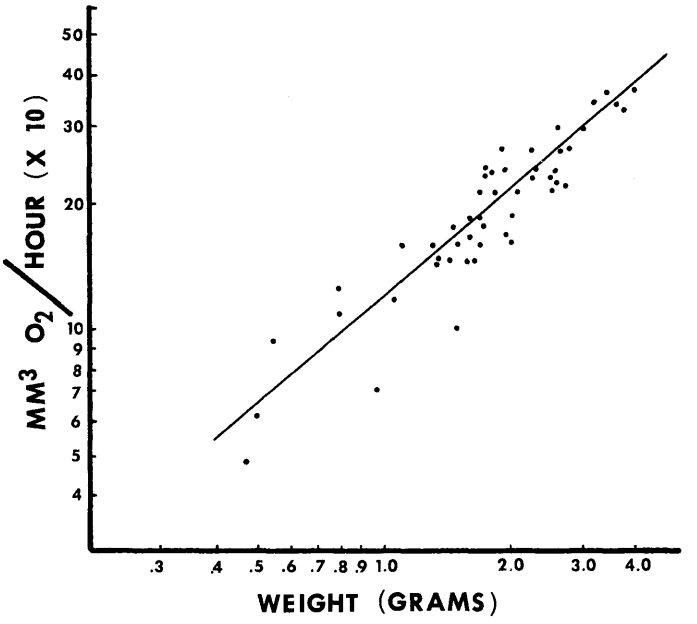


FIGURE 1. The relation between oxygen consumption and body weight of the 8L group.

TABLE 1

*Oxygen consumption in three photoperiod groups*

| Group | Sex | Number of Animals Tested | Mean Weight (grams±SE) | MM³ $O_2$/gram-hour | |
|---|---|---|---|---|---|
| | | | | Range | Mean±SE |
| 0 L | both | 51 | 1.97±0.11 | 26.6–157.6 | 105.96±3.21 |
| 0 L | males | 30 | 2.13±0.17 | | 108.42±4.19 |
| 0 L | females | 21 | 1.73±0.42 | | 102.13±5.02 |
| 8 L | both | 54 | 1.95±0.16 | 78.7–177.1 | 109.70±2.76 |
| 8 L | males | 39 | 1.99±0.14 | | 109.40±3.26 |
| 8 L | females | 15 | 1.85±0.21 | | 110.55±5.31 |
| 16 L | both | 47 | 1.68±0.11 | 73.5–166.2 | 114.39±3.05 |
| 16 L | males | 25 | 1.76±0.19 | | 111.61±4.33 |
| 16 L | females | 22 | 1.39±0.15 | | 117.56±4.28 |

*Relationship of Oxygen Consumption to Photoperiod*

An analysis of the oxygen consumption for each group is presented in table 1. The means within and between groups were compared by the t-test, using the 0.05 probability level as a criterion for significance. The 16 L group had significantly higher oxygen consumption than the 0 L group ($t=1.87$, $P<0.05$). Comparisons of the 16 L and 8 L groups, and of the 8 L and 0 L groups, revealed no significant differences ($t=1.13$, $P<0.15$ and $t=0.88$, $P<0.2$, respectively). When the sexes were separated for intragroup and intergroup comparisons, it was apparent that the differences between the 0 L and 16 L groups resulted from differences between

females and not between males (figure 2). Significant differences were not found to exist between the sexes in intragroup comparisons nor between males in intergroup comparisons, but differences were found between females in the 0 L and 16 L groups ($t=2.35$, $P<0.02$). The coefficient for the regression of oxygen consumption upon photoperiod for females was found to differ significantly from 0 while the coefficient for males indicated only a random deviation from 0.

Without further study, one can only speculate that short photoperiods in females may inhibit öogenesis and consequently reduce metabolism, while longer photoperiods may have the opposite effects. If sperm production requires less energy than egg production, it is reasonable that a correlation between photoperiod and oxygen consumption in males would be very weak or non-existent, as observed in this study. To resolve this problem, the stimulatory effect of photoperiod on gametogenic cycles in salamanders must first be demonstrated. Studies of this type are now being conducted in our laboratory.

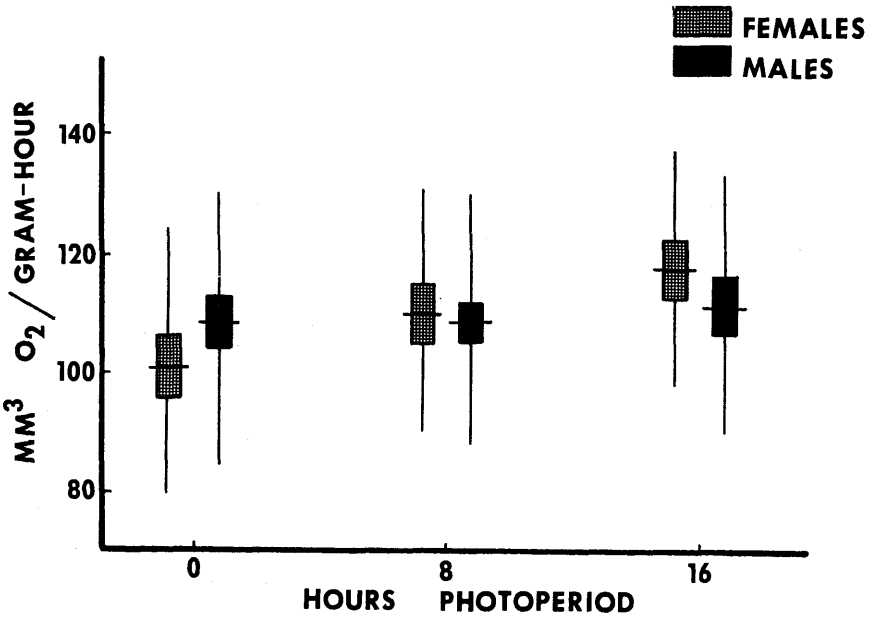


FIGURE 2. The relation between oxygen consumption and photoperiod in males and females (vertical lines represent standard deviations, horizontal lines the means, and rectangles the standard errors).

To test the suggestion of Whitford and Hutchison (1965), that suddden exposure to light may stimulate the respiration of dark-acclimated salamanders, the oxygen consumption of ten animals from the 0 L group was determined for two hours in the dark and, immediately afterward, for two hours in the light. The mean oxygen consumption as determined in the dark was 105.7 $mm^3O_2/gm$ hr, while the mean when determined in the light was 112.8 $mm^3$ $O_2/gm$ hr. The difference between these means is highly significant ($t=4.58$, $p<0.001$).

Because salamanders of the genus *Desmognathus* are nocturnal and are found under rocks, logs, leaf litter, or in seepage banks during the day, it must be concluded that, if effects of photoperiod do occur in nature similar to those obtained in this study, the threshold at which the animals respond to light intensity must be quite low. An experimental test of the relation of light intensity to photoperiodic metabolic responses would be necessary and valuable in elucidating the

relationship between the photoperiodic responses obtained in this study to the ecology of these amphibians.

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