ACTA BIOLOGICA SZEGED. 24 (1–4), pp. 111–114 (1978)

RESPIRATION AS ONE OF THE MANIFESTATIONS OF THE GROUP EFFECT IN ANTS

L. GALLÉ, Jr.

Department of Zoology, Attila József University, Szeged
(Received November 15, 1977)

Abstract

The oxygen consumption of workers of *Camponotus vagus* LATR., *Formica pratensis* RETZ., *Formica cunicularia* LATR. and *Formica fusca* L., measured with Wartburg's technique in the interval 15—35 °C, varies with the temperature according to a logistic curve. The O_2 consumption measured in $\mu l \cdot mg^{-1} \cdot h^{-1}$ is inversely proportional to the number of worker ants put in one respiration chamber. This connection may be described by a hyperbolic curve. If the individual number increases, the hyperbola approaches a particular "group respiration" value.

Introduction

Study of the ecological energetics and production biology of ants necessitates the determination of the quantity of energy (R) released in the course of respiration. Many papers published on this subject therefore deal with respiration from an energetical approach. GOLLEY and GENTRY (1964) measured the oxygen consumption in a bioenergetical investigation of *Pogonomyrmex badius*. MALDAGUE et al. (1967) studied the respirations of five Canadian ant species as a function of temperature. As regards the European species, first the respiration of *Formica polyctena* was measured by SCHMIDT (1967), then that of *Lasius alienus* by NIELSEN (1972). JENSEN and NIELSEN (1975) examined the oxygen consumption in eight ant species as a function not only of temperature, but also of body-size.

The aim of the present investigations was to investigate the temperature-dependence of the respiration, and also to measure the difference between the oxygen consumptions of solitary ant workers and those staying in a group, on *Camponotus vagus* LATR., *Formica pratensis* RETZ., *F. cunicularia* LATR., and *Formica fusca* L.

Warburg'a technique was applied at temperatures between 15 and 35 °C. On each occasion, ten parallel measurements were performed and four further vessels were used as thermobarometers. Depending upon the species and individual number, the individuals put in the respirometer were made accustomed to the respirometer for 1 to 14 hours before measurement, so that the results should not be influenced by the excitement of being put into the equipment. A total of 504 measurements were made.

Results and Discussion

JENSEN and NIELSEN (1975) found a correlation of the form

$$\log y_w = 0.0491\,t - 0.9111$$

between the temperature and the oxygen consumption in the interval between 5 and 25 °C. The present investigations show that in the range between 15 and

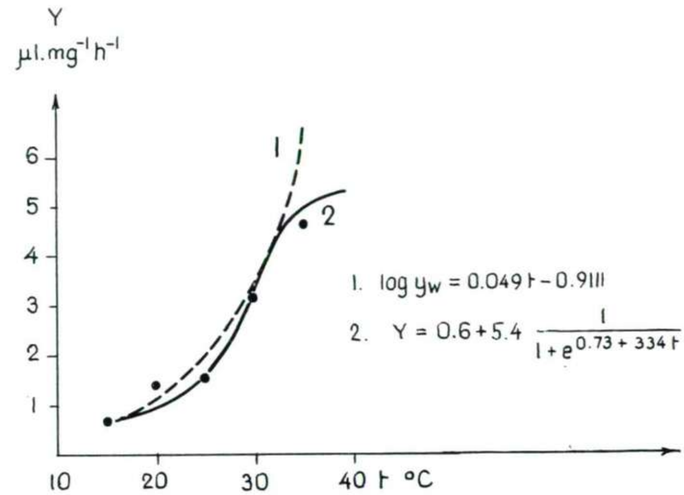

Fig. 1. Comparison of Jensen and Nielsen's (1975) equation (1) with the values obtained for *Formica fusca* (2).

35 °C the correlation can be better approximated to by a logistical function (Fig. 1). The functions obtained for the individual species were as follows:

Formica cunicularia:

$$Y = 0.45 + 3 \quad \frac{1}{1 + e^{16.3 - 0.6523t}}$$

Formica pratensis:

$$Y = 1.70 + 3.1 \frac{1}{1 + e^{13.74 - 0.547t}}$$

Formica fusca:

$$Y = 0.60 + 5.4 \frac{1}{1 + e^{0.73 - 0.334t}}$$

Camponotus vagus:

$$Y = 1.00 + 4.1 \frac{1}{1 + e^{7.694 - 0.345t}}$$

where Y = the oxygen consumption in $\mu l \cdot mg^{-1} \cdot h^{-1}$, calculated on the dry weight; $e=2.718$, the base of natural logarithms; t=temperature in °C; the significance of fitting of the data measured to the function for *F. cunicularia* is $p<0.1$; for *F. pratensis* $p<0.05$; for *F. fusca* $p<0,01$, and for *C. vagus* $p<0.001$. A sigmoid curve was obtained by CSOKNYA (1973) and CSOKNYA and HALASY (1975) for the connection between temperature and respiration for *Palingenia,* as well.

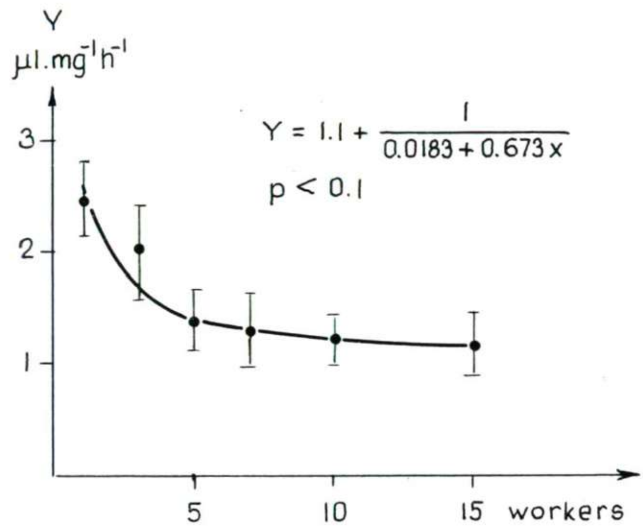

Fig. 2. The function obtained for the correlation between the individual number of *F. cunicularia* and the O_2 consumption.

In the investigation into the connection between the individual number in a respirator chamber and the oxygen consumption, 1, 2, 3, 5 or 10 ant workers were placed into a chamber at 25 °C and the respiration was measured. In addition 7 and 15 individuals were also applied in the case of *F. cunicularia*; with *C. vagus,* on the other hand, for technical reasons the maximum number of individuals was five. An inverse proportionality was found for the connection of the individual number and the respiration, approximated to by a hyperbolic function. Figure 2 shows the data obtained for *F. cunicularia.* The hyperbolic approximation is non-significant ($p>0.1$) only in the case of *F. pratensis,* and thus, instead of the equation:

$$Y = 0.71 + \frac{1}{0.526 + 0.246\,x}$$

the straight line $Y=2.215-0.149x$ means a mathematically better approximation ($p<0.05$); however this would mean that for a certain individual number there would be no oxygen consumption, and therefore, from biological considerations, even in this case the hyperbolic approximation is considered more suitable.

WILSON (1971), refining GRASSÉ's definition, suggested the following definition of a group effect: "a group effect is an alteration in behavior or physiology within a species brought about by signals that are directed in neither space nor time". In this sense the effect of the individual number on the respiration, as a non-directed physiological alteration appearing in a group, must be classified as a group effect.

In the respiration, as a manifestation of the group effect, two values in particular are held to be important:

1. The individual number at wich the slope of the hyperbolic curve suddenly decreases. This "critical individual number" was generally five for the species investigated, but 6—7 for *F. pratensis*.

2. The oxygen-consumption value approximated to by a hyperbola is the value of the "group respiration" characteristic of the species. This was 0.7 *(F. fusca)*, 1.0 *(F. pratensis)*, 0.8 *(C. vagus)* and 1.1 *(F. cunicularia)* $\mu l \cdot mg^{-1} \cdot h^{-1}$.

References

CSOKNYA, M. (1973): Experimental investigations of the respiration of nymphs of *Palingenia longicauda* OLIV. (Ephemeroptera). — Tiscia (Szeged) *8*, 47--51.

CSOKNYA, M., HALASY, K. (1975): Experiments for determining the oxygen consumption of nymphs of *Palingenia longicauda* (Ephemeroptera). — Tiscia (Szeged) *10*, 51—54.

GOLLEY, F. B., GENTRY, J. B. (1964): Bioenergetics of southern harvester ant, *Pogonomyrmex badius*. — Ecology *45*, 217—225.

JENSEN, T. F., NIELSEN, M. G. (1975): The influence of body size and temperature on worker ant respiration. — Natura Jutlandica *18*, 21—25.

MALDAGUE, M. E., HARDY, Y., DEMERS, J. (1967): Influence de la température sur la consommation d'oxygéne chez différentes espéces de Fournis. — Pedobiologia *7*, 247—258.

NIELSEN, M. G. (1972): An attempt to estimate energy flow through a population of workers of *Lasius alienus* (FÖRST.) (Hymenoptera: Formicidae). — Natura Jutlandica *16*, 99—107.

SCHMIDT, G. H. (1967): Veränderungen im Gehalt an energieliefernden Reservestoffen während der Kastendifferenzierung von *Formica polyctena* FOERST. Ins. (Hym.). — Biol. Zentr. *86*, 5—66.

WILSON, E. O. (1971): The insect societies. — Harvard University Press, Cambridge, Mass.

Address of the author:

Dr. L. GALLÉ Jr.
Department of Zoology, A. J.
University, H-6701 Szeged,
P.O. Box 428,
Hungary