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ENERGY TURNOVER IN A POPULATION OF THE ANT *Lasius flavus* F.

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RESUME : Circulation de l'énergie dans une population de la fourmi *Lasius flavus* F.

Afin d'illustrer l'importance de *Lasius flavus*, on a fait des estimations sur la circulation de l'énergie dans une population moyenne, dans un écosystème représentatif d'un terrain calcaire.

La densité des colonies a été enregistrée sur des territoires variés. Dans les échantillons de colonies, les populations d'ouvrières ont été estimées par le procédé de marquage et recapture. On a calculé la production de sexués de ces colonies en se basant sur des captures répétées des adultes. Le poids des fourmis sèches et la quantité d'énergie contenue dans les castes ont été calculés.

Si l'on suppose que le renouvellement annuel des ouvrières est de 1, la production annuelle d'une colonie moyenne est estimée à 138 KJ ou 27 KJ m^{-2} an^{-1}.

Des estimations de l'assimilation de l'énergie ont été faites en appliquant des équations qui tiennent compte de la production et de la respiration annuelles. La respiration et la production annuelles (assimilation) ont été estimées à 91 KJ m^{-2} an^{-1}, après calcul à partir d'une nouvelle équation.

Si le rendement de l'assimilation se situe entre 0,5 et 0,7, la circulation de l'énergie d'une population de *L. flavus* se situe alors entre 1 et 1,4% de la production primaire d'un terrain calcaire à la surface du sol.

Ceci représente un chiffre considérable pour une espèce particulière et indique l'importance de *L. flavus* dans l'écosystème du terrain calcaire. Les calculs et les hypothèses, que l'on a également faits, indiquent la nécessité de connaissances fondamentales plus complètes sur l'énergétique des fourmis.

Mots-clés : *Lasius flavus*, terrain calcaire, circulation de l'énergie.

SUMMARY

Energy turnover in a population of the ant *Lasius flavus* F.

The worker population and sexual production of a sample of colonies of the ant *Lasius flavus* have been measured. By making a variety of assumptions about the energetics of this species and using predictive equations, an estimate has been made of the annual energy turnover of *L. flavus* on chalk grassland. This estimate is equivalent to 1 to 1.4% of above ground primary production of chalk grassland.

Keywords: *Lasius flavus*, chalk grassland, energy turnover.

INTRODUCTION

Lasius flavus F., a common European ant, is often found in dense populations on chalk grassland. It appears to have a great influence on the ecosystem in which it lives (King 1977), a characteristic it shares with many other social insects. There are, though, few figures on the relative importance of social insects, in energetics terms, which can be used to support this idea.

This paper aims to make such an estimate for a typical population of *L. flavus* on chalk grasland in the south of England, thereby illustrating its importance in its ecosystem. Some of the difficulties in reaching such an estimate will also be pointed out.

MATERIALS AND METHODS

In 20 sample quadrats, each 20 x 20 metres square, the number of occupied soil mounds, each corresponding to one ant colony, were counted. The quadrats came from areas of varying environment and management, at four locations, Old Winchester Hill, Martin Down and Saint Catherines' Hill in Hampshire and Aston Rowant in Oxfordshire.

For a sample of colonies (35), the size of the worker populations were estimated using mark-release-recapture, with phosphorus 32 as the marker (Wright 1987). From the same colonies the numbers of sexuals (males and gynes) produced over 2 years was found by repeated capture. The energy contents of dried samples of workers, males and gynes (7 days at 105°C) were measured by bomb calorimetry.

RESULTS

The mean number of colonies in a 20 x 20 metre quadrat was 78. The estimated mean colony size was 14,000 worker ants. The mean number of sexuals produced per colony per year was 899 +/- 652 males and 141 +/- 114 gynes.

The mean dry weights of an individual of each of the castes were measured to be:-

Gynes	9.29 mg
Males	0.33 mg
Workers	0.32 mg

In Table 1, below, the dry weight of the total population of each caste for the mean colony, the energy contents, as estimated by the bomb calorimetry, of 1 gram of each caste, and then the calculated mean energy content of each caste in the mean colony are given.

Caste	Dry wt (g)	Energy content KJg^{-1}	Total energy content KJ
Gynes (141)	1.305	32.1	41.9
Males (899)	0.297	23.1	6.8
Workers (14,000)	4.480	20.2	90.1
			total 138.8

Table 1. Summary of the energy content of a colony.

Tableau 1. Résumé de la masse d'énergie contenue dans un colonie.

DISCUSSION

In order to estimate the annual energy turnover in the average colony a number of calculations and assumptions have to be made.

Firstly, if an annual worker turnover rate of 1 is assumed, (this being well within the range noted for other species, although data is scarce, Petal 1978), then the average colony produces 14,000 workers, 141 gynes and 899 males, a total annual estimated production (P) of 138.8 KJ. This estimate only takes account of the large factors contributing to production and ignores several minor ones such as the pupal coccoons. It was felt however that these were insignificant compared to those for which estimates have been made.

As there was a mean of 78 colonies per quadrat of 400 m^2 then this level of colony production was equivalent to 27.1 KJ m^{-2} yr^{-1}.

No measurements were made on the respiration of the ants and therefore this was estimated using predictive equations. McNiell and Lawton (1970) were the first to relate the annual production of an animal to its respiration. They collated data from a wide range of species and used it to produce several equations relating annual production and respiration. Their equation for long lived poikilotherms is given (1). Subsequently Jensen (1978) analysed the known data on production and respiration for species of ant and concluded that this equation fitted well.

Humphries (1979) extended this work with a far ranging review of the animal kingdom. He produced an equation, (2), which related production and respiration for social insects, although they were included in with fish. His data on ants was limited to 4 estimates for *Pogonomyrmex occidentalis* Cresson and 1 for *Lasius alienus* Foerst.

Finally I have taken the figures used by Jensen (1978), included some more recent ones and recalculated an equation for this data (3).

The three equations run as follows;

1) $\log R = 1.073 \log P + 0.376$

R and P measured in Kcal $m^{-2} yr^{-1}$

As $P = 27.1$ KJ $m^{-2} yr^{-1} = 6.5$ Kcal $m^{-2} yr^{-1}$

$R = 75.6$ KJ $m^{-2} yr^{-1}$

2) $\log R = 0.839 \log P + 1.504$

R and P measured in cal $m^{-2} yr^{-1}$

As $P = 27.1$ KJ $m^{-2} yr^{-1} = 6{,}470$ cal $m^{-2} yr^{-1}$

$R = 210.5$ KJ $m^{-2} yr^{-1}$

3) $\log R = 0.827 \log P + 1.140$

R and P measured in Joules $m^{-2} yr^{-1}$

As $P = 27.1$ KJ $m^{-2} yr^{-1} = 27{,}100$ J $m^{-2} yr^{-1}$

$R = 64.2$ KJ $m^{-2} yr^{-1}$

Thus three different figures are generated for R. The results of equations 1 and 3 are quite close but that of equation 2 gives a much larger figure. Bearing in mind that equation three is based on data from ant species only it is perhaps the most reliable one in this case. The use of Humphreys predictive equation for social insects and fish could be inaccurate for ant species alone.

Using the results of equation 3, annual assimilation (A) being the sum of R and P = 91.3 KJ $m^{-2} yr^{-1}$. This gives a production efficiency of 29.7%.

Assimilation efficiency for this species is also unknown, but if it assumed to be about 0.5, then consumption = 182.6 KJ $m^{-2} yr^{-1}$. If it is assumed to be 0.7 then it is 130.4 KJ $m^{-2} yr^{-1}$.

Williamson (1976) estimated the above ground primary production of a typical chalk grassland at 13,317 KJ $m^{-2} yr^{-1}$. Thus the ant energy flow could very easily be between 1 and 1.4% of the energy coming into the ecosystem.

This can be considered a high figure for an individual species, particularly if it is considered how little of the primary production of an ecosystem is usually passed on to each successive trophic level (10 to 20%, Odum 1971). In other ant species for which such calculations have been done figures of a similar order have been obtained. The energy consumption of a population of *Lasius alienus* was estimated at 272 KJ $m^{-2} yr^{-1}$ (Nielsen 1972), and of *Formica polyctena* Foerst 339 KJ (Horstman 1974). It indicates the important part that *L. flavus* must play in this ecosystem and is more evidence of the important energetic as well as ecological role that ants have in ecosystems.

The calculations and assumptions made above could all be improved by more and better data for a wide variety of ant species. More basic work needs to be done before such asssumptions can be considered reliable enough.

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