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DATA ON THE ECOLOGICAL ENERGETICS OF FORMICA PRATENSIS RETZ. (HYMENOPTERA: FORMICIDAE) IN THE PSAMMOPHILE ECOSYSTEMS OF THE SOUTHERN HUNGARIAN PLAIN

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Abstract

The polygynous and polycalic colonies of *Formica pratensis* RETZ. occur in grassland ecosystems, but the workers collect a large part of their food in the nearby planted woods of *Pinus silvestris*. In this way, they establish a contact of material flow between the two different ecosystem types. A maximum can be observed at the end of May and early June in the annual course of their feeding activity, and at 9 and 14 o'clock in daily rhythm. On a single occasion the foragers consume food amounting on average to 19.3 per cent of their body weight, that is 0.485 mg (1.902 cal) in dry weight. The annual consumption of a colony of a hundred thousand individuals ($1.13 \cdot 10^5 - 2.04 \cdot 10^5$), consisting of 12 nests, selected for investigations into their food consumption, is between 13,08 and 22.63 kg. This means as referred to the feeding area, an amount of 2.54—4.39 g/sq m (9967 to 17 524 cal/sq m). *F. pratensis* mostly take part (48.4 per cent) as secondary and tertiary consumers in the grazing food chain, but their honeydew consumption is also very considerable (39.2 per cent). The elimination of the population is mostly caused by the woodpeckers *Picus viridis* L. and *Dendrocopus major* L., by the activity of wich the populations of nests can be reduced by about a half. Owing to the woodpecker-induced elimination, a minimum 1.6 per cent ecological effeciency (100 P/C) is necessary to ensure the survival of colonies in an unchanged size.

Introduction

The particularly important role of ants in the material and energy flow in some ecosystems is proved by the results of research obtained so far in the course of structural and functional studies on terrestrial ecological systems. With his general model GÖSSWALD (1965) outlinex the activity of *Formica* s. str. species in the forest-ecosystems. In respect of *pratensis,* food consumption investigations were carried out by EIDMANN and STAEGER (STITZ, 1939). AYRE (1966) investigated the connection between the colony size and food consumption in three ant species, under artificial conditions. PETAL (1967, 1972) calls attention not only to the co-sumption and productivity parameters of *Myrmica laevinodis* NYL. population, but also to the role of ants in regulating the secondary production of grassland ecosystems, in her papers written with co-workers (PETAL at al., 1971; KAJAK et al., 1971, 1972). DLUSSKY and KUPIANSKAYA (1972) pointed out the importance of protein food for *Myrmica* species. BRIAN et al. (BRIAN, 1967, 1972; BRIAN et al., 1967, 1974) have investigated the size, productivity and population turnover of populations of *Tetramorium ceaspitum* LATR. and *Myrmica* species in the lowland plains of Southern England. NIELSEN (1972a, b, 1974a, b, 1975) has examined the productivity and energy flow of *Lasius alienus* populations in the psammophile ecosystems of Denmark. The energetics of *Pogonomyrex badius* were elaborated by GOLLEY and GENTRY (1964) in old fields.

In respect of the *Formica pratensis* species, laboratory investigations into ecological energetics were performed by HORN (1972). GALLÉ (1973, 1976a) described the thermoregulation and rhythm of the feeding activity in the nests of this species.

Formica pratensis is the only considerable species of the grassland and forest ecosystems in the Hungarian plain, belonging to the *Formica* s. str. subgenus. The aim of the present investigations was to determine the food consumption and other ecological energetics parameters of this ant species under natural conditions.

Materials and Methods

The investigations were performed between 1971 and 1975, into ant colonies in the *Astragalo-Festucetum sulcatae* and *Festucetum vaginatae stipetosum* ecosystems.

The colonies were of polycalic and polygynous character. A large part of the food was collected by the workers in the nearly planted *Pinus silvestris* grove. Thus apart from the role of pratensis establishing a contact of the material flow for both types of ecosystems between the natural grassland and the planted wood, their ecological role in the lowland pine plantations can also be concluded from the results of the investigations.

The food consumption was measured in full in a polycalic colony, consisting of eight major and four smaller permanent nests and a number of provisional branch nests. In other colonies only "point investigations" have been performed with the intention of comparing these.

In the course of measuring the food consumption, we considered assessment of the following parameters as most important:

1. The rhythm of feeding activity of the colony.
2. The amount of material removed (MR) and really consumed (C) by individuals.
3. The qualitative composition of the food.

The seasonal and daily rhythms of feeding activity were established on the basis of numerical fluctuations of the individuals leaving and returnung the colony on the food-ways (GALLÉ, 1976).

The quantity of material removed (MR) and the consumption (C) were estimated on the basis of difference of the individuals leaving the colony hungry and those returning with full crops, in each case with a minimum of thirty individuals. Taking into consideration that the difference in weight between the hungry individuals and those returning with food can also be a result of a constitutional difference, in order to avoid any mistake, we corrected the weight-data by means of the head-width index, which is proportionate to the size of the individuals. According to this, the consumption value is to be determined in the following way:

$$C = g_c - \frac{1}{h_o} \cdot g_o \cdot h_c$$

where C=consumption; g_c=dry weight of the individual returning with food; g_0=the average starving weight, its value being 2.4089 mg; h_c=the average head-width, *i.e.* the head-width of the individuals representing the average starving weight. To the 2.4089 mg average individual weight a head-width of 1.65 mm belongs. With this method, having duly exact g_0 and h_0 data, we could establish even the food amount consumed by a single ant. The weight of the material quantity removed (MR) was calculated from the weight of the food remainder carried into the nest in the mandibles but not being consumed, too.

The qualitative composition of the food was also determined from the food remainder carried into the nest in the mandibles. However, ants carry the largest part of their food not in the mandibles but in the crop, the "social stomach". It is supposed by some authors that the food carried in the mandibles is the insect food and the excretion of Aphids is carried into the nest in their crop. With regard to the fact that the amount of material carried in the crop is the vast majority of the MR, it seemed to be necessary to analyse the contents of the crop as well, in order to decide whether they contained sugar or some food of other character. The analysis of the crop contant was carried out with a simple sugar-test by means of guttadiaphot (SZALAI—FRENYÓ, 1962); hence it could be decided what percentage of the individuals returning into the nest had consumed honeydew.

The number of individuals in the nests necessary for determing B_0 was estimated with Lincoln's index, and the number of feeding individuals was determined with a method based essentially upon Horstmann's investigations (1974), assuming that the active feeders leave the nest, in the case of two activity maxima daily, twice a day. With regard to the very high individual number in the colony both estimations have an informative character rather but in relation to the order of magnitude.

To determine the elimination (E), the nests were covered with guard-nets, to keep the woodpeckers off (1972—1973), and after removing the nets we assessed the decrease in the number of colony by means of the decline in the number of feeding individuals.

The material quantities figuring below are everywhere given in dry weight. The calorific contents of biomass amounts, as well as those of the other substances occuring, were determined with Phillipson's Gentry-made microbomb calorimeter with combustion in oxygen in the bomb under 35 atm.

The denomination and interpretation of the parameters in the material and energy flow of the population are applied according to PETRUSEWICZ (1967a, b), as well as PETRUSEWICZ and MACFADYEN (1970).

Results

The results of the feeding activity were reported in an article published previously (GALLÉ, 1976a). According to this, the feeding activity changes seasonally and in a daily course, as well. In an annual relation, a peak develope in late May or early June, in the daily course, two maxima can be observed, at about 8—9 a.m. and 2—3 p.m.

The dry weight of the food consumed by the individuals is on average $19.3\pm\pm3.66$ per cent of the weight of the feeding workers. This is 0.485 ± 0.087 mg, or 1.902 cal individually. The food amount consumed by the full colony changes in parallel with the rhythm of the feeding activity. In accordance with the higher number in the colony ($2.04\cdot10^5$ individuals), in the years when a stronger protection was ensured by the net, the material amount consumed was also larger; it varied between 68 and 419 g/day during the year, while after removal of the nets a colony of $1.13\cdot10^5$ consumed between 13.85 and 131.90 g/day (Fig. 1).

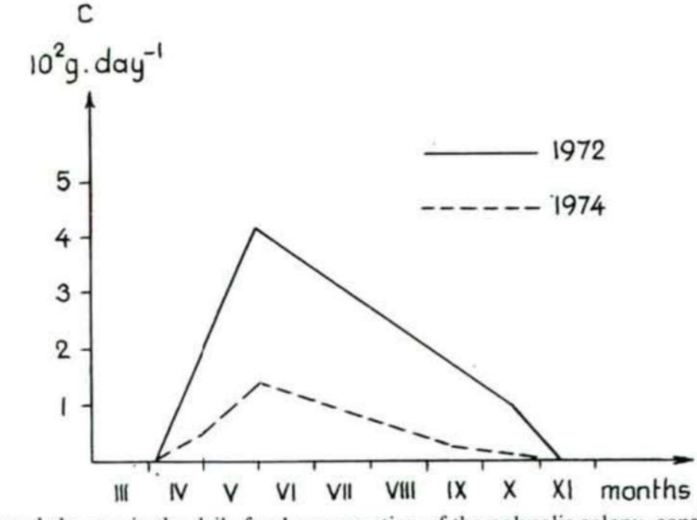

Fig. 1. Seasonal changes in the daily food consumption of the polycalic colony, consisting of twelve permanent nests of *Formica pratensis*, in natural (1974) and net-covered states (1972).

The cological role of *Formica pratensis* can be established on the basis of the qualitative composition of the food. The vegetable parts amount 4.98 per cent of the materials carries into the colony (Table 1). This is, therefore, the primary consumer activity of pratensis. As, however, it does not consume the decisive majority of these substances, but probably uses them for building nests, this amount is NU from the point of view of the population. This species is active as secondary consumer of the grazing food chain in 36.11 per cent of the total MR. From among the pytophages consumed, the *Lepidoptera* larvae amount to 35.09 per cent. In addition predation of *Aphidina* is also very considerable (23.24 per cent). From among the beetles, representing a very high ratio (14.91 per cent of the total phytophages, Table 2), *Peritelus familiaris* amounts to 6.14 per cent, i.e. approximately half of all beetles consumed. The tertiary consumer activity is 12.40 per cent of the total activity (Table 1); from the secondary consumers pratensis cosume other *Formicidae* in largest quantity (Table 3); these mean 64.61 per cent of the food cosisiting of secondary consumers, 7.403 per cent of the total food. The *Formicidae* consumed are: *Leptothorax unifasciata* LATR., *Lasius alienus* FÖRST., *Lasius emarginatus* OL., *Lasius brunneus* LATR., *Formica cunicularia* LATR., and *Formica fusca* L.

The participation in consuming detritus means 7,3 per cent of the food of

Table 1. Percentage distribution of the ecological activity of *Formica pratensis*

activity	per cent
primary consumer	4.979
secondary consumer	36.112
tertiary consumer	12.398
decomposer	7.330
honeydew	39.180
total	99.999

Table 2. Percentage composition of the foodstuffs consumed in the course of secondary consumer activity of Formica pratensis. The foodstuffs specified according to insect orders originate from 42 primary consumer niches. n = 228

type of food	per cent
Orthoptera	3.508
phytophagous Heteroptera	3.508
Aphidina	23.245
other Homoptera	1.315
Coleoptera adults	14.912
Coleoptera larvae	0.877
Lepidoptera adults	0.877
Lepidoptera larvae	35.087
Lepidoptera pupae	0.438
Diptera	9.649
Hymenoptera	3.508
Others	3.070
total	99.994

Table 3. Activity of the tertiary consumer *F. pratensis*. The foodstuffs specified originate from 24 different secondary consumer niches. n=65

type of food	per cent
carnivorous Heteroptera	1.538
Neuroptera	6.153
Coleoptera	6.153
Diptera	3.076
Formicoidea	64.615
other Hymenoptera	6.153
Araneidea	12.307
total	99.995

Table 4. The decomposing activity of *F. pratensis*. n=21

type of food	per cent
Isopoda	14.285
Diplopoda	23.809
Blattidea	14.285
Coleoptera	19.047
Acari	14.285
material regurgitated by birds	14.285
total	99.996

Formica pratensis. Within this, it removes the corpses of insects and other animals, primarily by consuming the *Diplopoda, Isopoda,* and *Coleoptera* corpses (Table 4). The consumption of the animal of other origin (bird-regurgitation) is comparatively subordinate: 14.29 per cent of the decomposing activity and 0.53 per cent of the total food. The cosumption of honeydew is also to be included in the decomposing activity, amounting, according to the sugar test, to 39.1 per cent of the total food (Table 1).

The total biomass of the colony in 1972—1973 was on average 493.54 g (2615.7 kcal), represented by 204 thousand. This number was reduced in 1974, after removal of the guard-nets, to 113 thousand, with 273.84 g (1451.3 kcal). On the basis of this, it can be established that value B was diminished by woodpeckers by approximately 50 per cent. In order, therefore, that the colony should remain unchanged or even increase, the ratio P/C must at any event be higher than 1,67 per cent, so much the more so because, apart from birds, there are other elimination inducing factors, as well. The ecological effeciency of about 2 per cent (ratio 100 P/C) is characteristic of ants according to other ant-energetics works too (Petal, 1974, Timár, 1974, Gallé, 1976). From among the two woodpecker species already mentioned, the more considerable predator of *Formica pratensis* is *Picus viridis*. As regards other birds, *Parus major* L. and *Passer montanus* L. also feed in the nests of pratensis occasionally. According to de BRUYN et al. (1972), the green woodpecker consumes a maximum of 22—36 · 10^3 ants from the nest of *Formica rufa* L. in one winter; the average consumption however, is lower than this. According to the present investigations, 91,000 individuals perished as a result of the activity of woodpeckers. Taking into consideration the twelve nests, this is 7.58 · 10^3 ants a nest. In order of magnitude, this agrees therefore with the data of de BRUYN et al. As compared with the nest population of pratensis, however, many more individuals perished (44 per cent of the population of the colony) than it was observed by de BRUYN et al in the case of rufa, where this ratio was about 5 per cent. In this high ratio in the case of pratensis, another factors besides the food consumption of woodpeckers may have been that in winter the nests are ventilated by woodpeckers which bore holes in the nests, in this way putting an end to their thermostatic control. Many workers perish as a result of this.

The material and energy flow of the *Formica pratensis* investigated may therefore be summarized as follows (Fig. 2): The annual consumption of the twelve

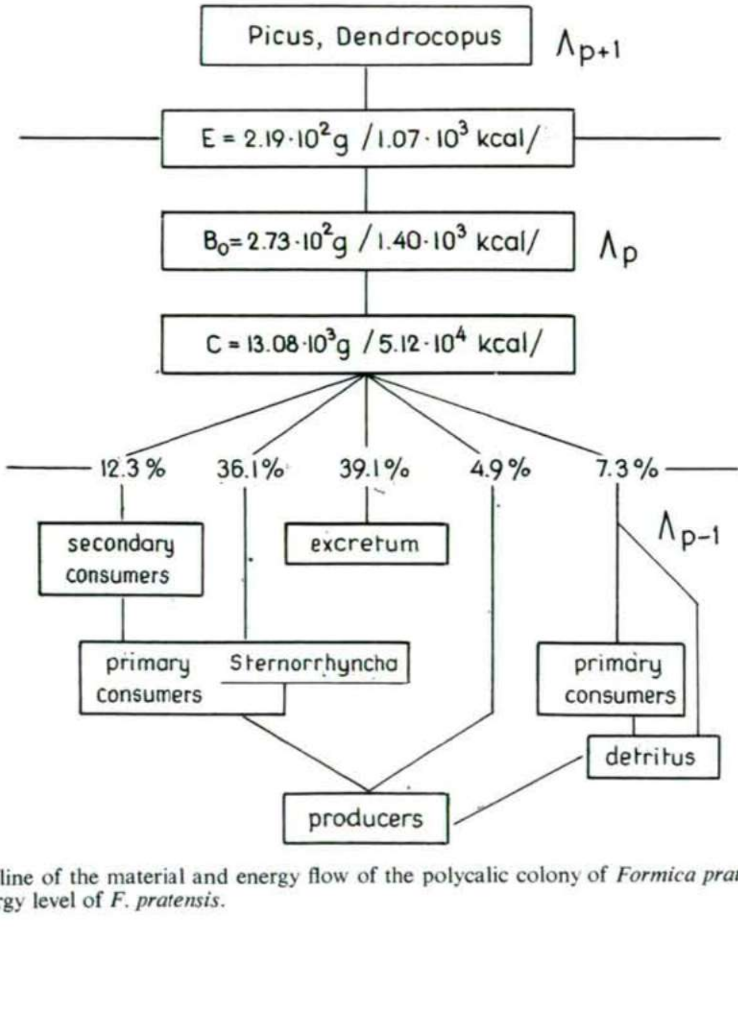

Fig. 2. Outline of the material and energy flow of the polycalic colony of *Formica pratensis*. Λp = energy level of *F. pratensis*.

nests creating the colony was 13.08 kg. This amount, if the individual number within nests is increased by applying guard-nets, as in the years 1972 and 1973, may increase to even 22.63 kg. It is shown by this that if we wish to increase the effeciency of the activity of *Formica pratensis,* for instance in order to give biological protection to pine-plantations, by using nets to eliminate woodpeckers, the volume of the consumption can be raised to almost the double. The above consumption data mean in a square metre quantities of 2.54 g (9967 cal) and 4.39 g (17 524 cal), respectively. The standing crop of the colony (B_0) was $2.73 \cdot 10^2$ g ($1.4 \cdot 10^3$ kcal); this, in a protected state, may rich $4.93 \cdot 10^2$ g ($2.6 \cdot 10^3$ cal). The extent of the bird-induced elimination (E) appeared to be $2.19 \cdot 10^2$ g ($1.07 \cdot 10^3$ kcal).

Conclusions

In the course of the investigation into the material and energy flow of the colony of *Formica pratensis,* the parameters B_0, C and E were determined.

1. *Formica pratensis,* in its ecological activity, is decisive by a secondary consumer. It plays a particular considerable role in regulating the secondary productivity of pine-plantations.

2. A considerable part of the food is honeydew (39.2 per cent).

3. The annual food consumption of the polycalic colony is of the order of 10^4 kcal.

4. Elimination is mainly induced by woodpeckers. Its value is of the order of 10^3 kcal a year.

5. The production necessary to preserve the colony is larger than $0.016 \cdot C$ a year.

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