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ADAPTATION OF ANTS TO INDUSTRIAL POLLUTION

ABSTRACT

Environmental pollution limited the size of ant communities, e.g. numbers of species, density of nests and numbers of individuals in colonies. The ants initiated processes leading to a decrease in pollution concentration in nests. These processes consisted in: a) accumulation of carbon and exchangeable cations, b) changes in humification — mineralization relations and c) stimulation of the growth of microorganisms removing the pollutants.

INTRODUCTION

The high resistance of ants to various kinds of environmental pollution accompanying the activities of man is a known fact. Ants are to a much greater extent resistant to the effect of radioactive rays [2, 5], insecticides [6], hormones used for plant protection [1] than other insects. They can also adapt to high industrial pollution [3, 5].

They develop different sorts of adaptation to the areas heavily polluted by nitrogen plant and sulphur mines. On these areas there is a great amount of nitrogen and sulphur compounds which causes high acidity of soil (pH 3.4—3.6) and thus destroys the vegetation to a large extent. The study was carried out along the gradient of declining pollution: at completely degraded zones, at zones restored by addition to soil of calcium, potassium and phosphorus and at the zones on the border of pollution. It took place at the beginning of summer (May—June 1973) and the following parameters were estimated: a) ant populations, i.e: species composition, density of ants nests, size of communities, turnover of biomass, b) soil habitat properties in anthills and in the same soil layers uninhabited by ants, i.e. soil respiration, the numbers of some microfloral groups, pH, amount of exchangeable cations, % of carbon and nitrate nitrogen concentration.

This paper is partly based on the data earlier reported by Jakubczyk [3] and Pętal [5].

CHANGES IN ANT POPULATIONS

Pollution with nitrogen and sulphur compounds limits first of all the size of ant communities. Of more than 20 species previously living in this areas only few remained, among which *Lasius niger* (L.), *Myrmica ruginodis* Nyl. and *M. schencki* Em. dominate. The density of their nests and numbers of individuals in a community is lower than on unpolluted areas and decreases with the increasing pollution (Tab. 1). Soil restoration (ploughing) damages anthills and decreases the number of individuals. This is especially visible in colonies of *L. niger* which has a developmental cycle more limited in time than the species of the genus *Myrmica*. At the beginning of summer the production and turnover of biomass in ant colonies are higher on areas with dust emission than in undamaged environments. This is due to the adaptation of larval development to a period when pollution has the least effect, and there is a maximum plant and animal food supply. This is best observed in habitats polluted by the nitrogen plant on sandy soils where water deficit and the increasing nitrate nitrogen concentration occur at the end of June.

Table 1. Changes of ant populations under influence of industrial pollution

Species	Variable	Nitrogen plant			Sulphur basin	
		devastated area	restored area	declining pollution area	devastated area	restored area
Myrmica ruginodis Nyl. and *Myrmica schencki* Em.	density of nests: (N/m^2)	0.001	0.02	0.05	0.03	0.05
	number of specimens in colony	738.0	759.0	998.0	593.0	255.0
	number of young specimens	263.5	386.0	264.0	206.0	91.0
	$P/\bar{B}$	0.14	0.16	0.07	0.15	0.22
Lasius niger (L.)	density of nests: (N/m^2)	0.06	0.10	0.15	0.06	0.25
	number of specimens in colony	210.2	53.0	1471.0	251.0	129.0
	number of young specimens	118.5	31.5	59.0	36.0	22.0
	$P/\bar{B}$	0.43	0.47	0.02	0.12	0.22

ADAPTATION OF SOIL HABITAT

Increasing pollution increases the acidity of soil and causes a decrease of total biological activity of soil. These processes are modified within anthills. The pH is controlled. The pH in the habitat (measured in KCl) is 1.9 to 4.4, in anthills 2.5 to 5.2 respectively. The regression equation shows that the highest pH increments in anthills in relation to pH of soil beyond the anthill are in most acid places (Fig. 1). It is interesting that the total biological activity of soil af anthills is lower than in the environment. The amount of used oxygen is 4.1—23.2 μl/g of soil/hr, whereas in the habitat it is 3.7 to 56.61 μl/g of soil/hr. Nevertheless, respiration in anthills increases much more than in the habitat after adding glucose to soil which causes the development of hibernating microorganisms. Regression equations expressing the relation between oxygen consumption of soil with glucose and soil without glucose in the habitat and anthills differ significantly (Fig. 2). This proves that there is considerable inhibition of microorganisms in anthills.

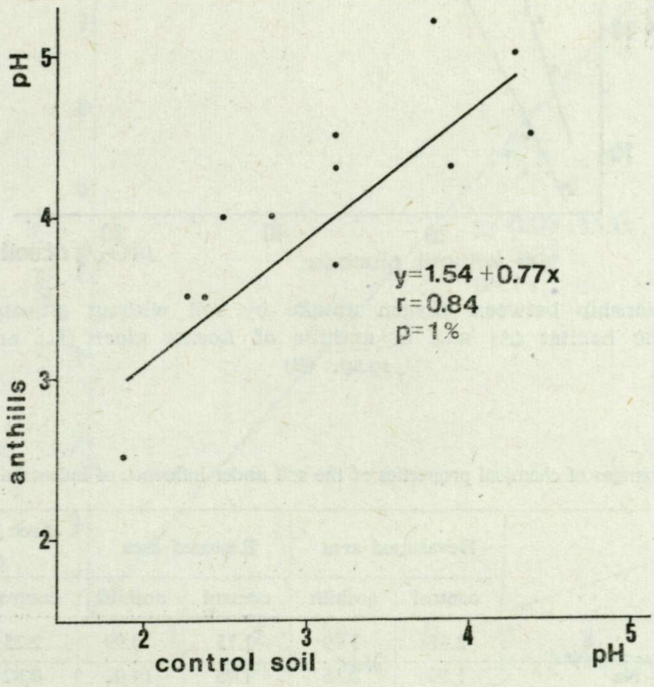

Fig. 1. Relationship between the pH in anthills of *Lasius niger* (L). and *Myrmica* sp.sp. and in the habitat

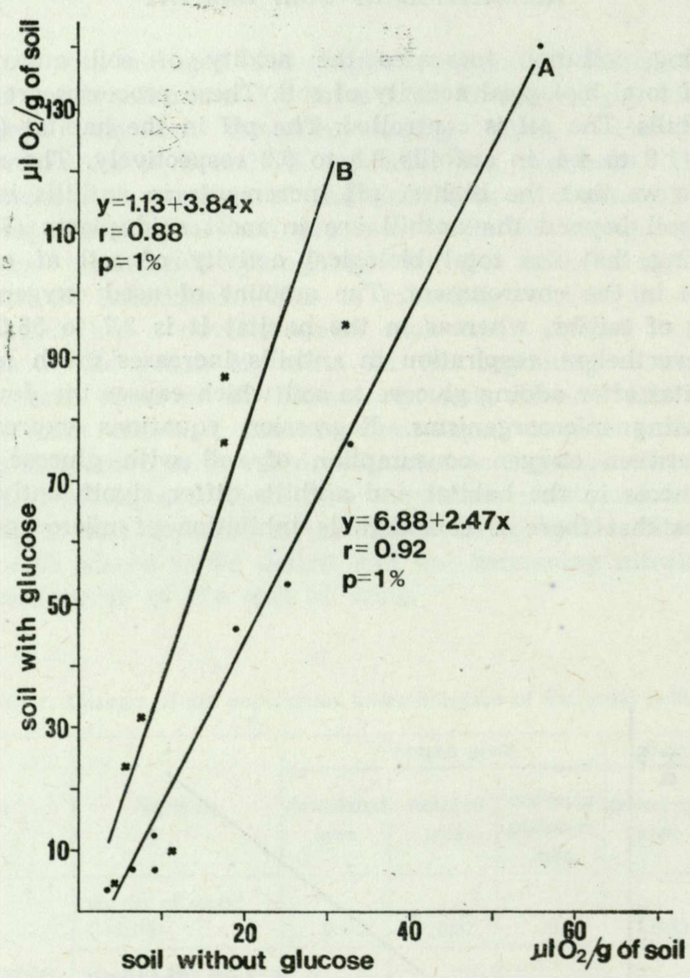

Fig. 2. Relationship between oxygen uptake by soil without glucose and with glucose in the habitat (A) and in anthills of *Lasius niger* (L.) and *Myrmica* sp.sp. (B)

Table 2. Changes of chemical properties of the soil under influence of industrial pollution

	Devastated area		Restored area		Area of declining control	
	control	anthills	control	anthills	control	anthills
% C	2.31	3.09	2.75	4.99	2.25	0.88
Ca+Mg+K+Na mg/100 g of soil	1.80	2.35	4.45	14.02	0.82	1.05
pH (in H_2O)	4.32	4.96	4.98	5.75	4.30	5.25

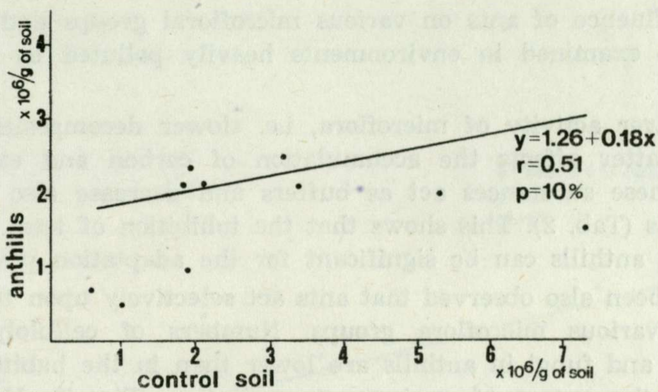

Fig. 3. Relationship between the numbers of fungi in anthills of *Lasius niger* (L.) and *Myrmica* sp.sp. and in the habitat

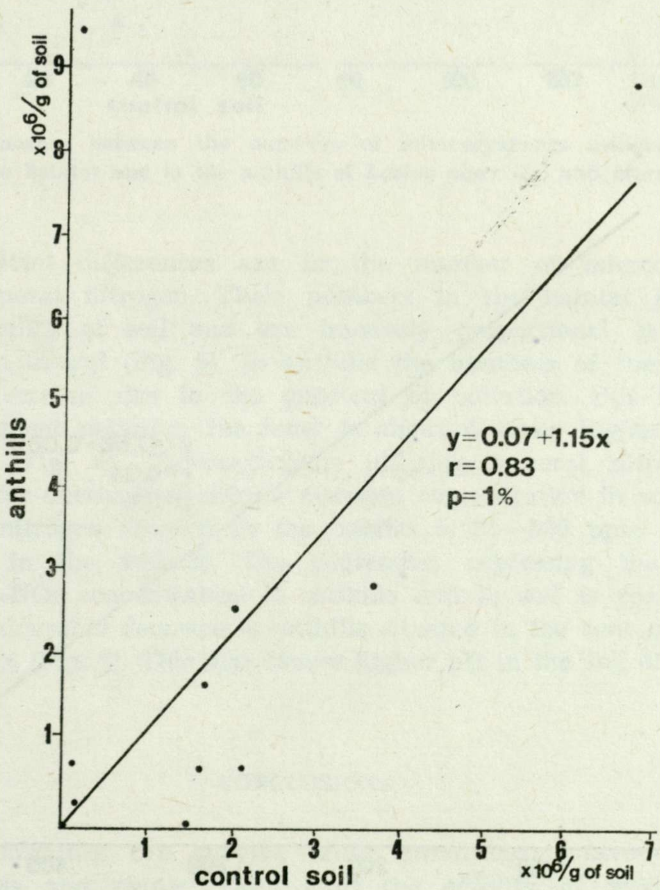

Fig. 4. Relationship between the numbers of *Actinomycetes* in anthills of *Lasius niger* (L.) and *Myrmica* sp.sp. and in the habitat

The influence of ants on various microfloral groups and its effects have been examined in environments heavily polluted by a nitrogen plant.

The lower activity of microflora, i.e. slower decomposition rate of organic matter affects the accumulation of carbon and exchangeable cations. These substances act as buffers and decrease also the pH in the anthills (Tab. 2). This shows that the inhibition of total microfloral activity in anthills can be significant for the adaptation process.

It has been also observed that ants act selectively upon the development of various microflora groups. Numbers of cellulolytic microorganisms and fungi in anthills are lower than in the habitat independently of the extent of environment pollution (Fig. 3). However the numbers of *Actinomycetes* decrease in the pollution gradient, but in most contaminated places they are higher in anthills than in the habitat (Fig. 4).

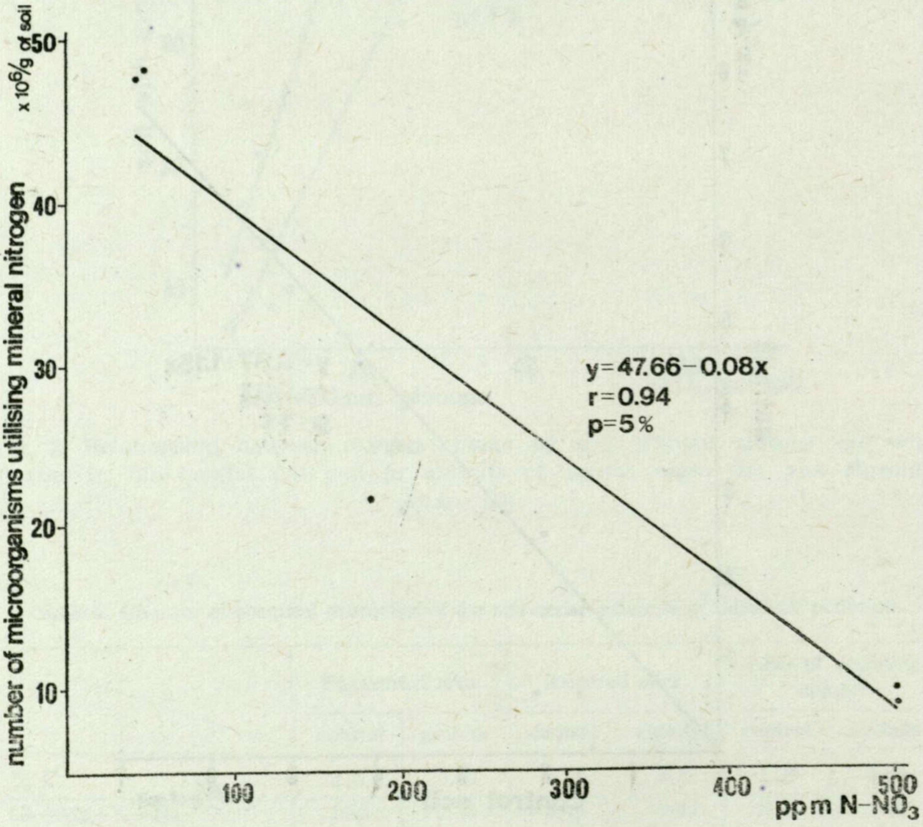

Fig. 5. Relationship between the content of nitrate nitrogen in the soil and the numbers of microorganisms utilizing mineral nitrogen

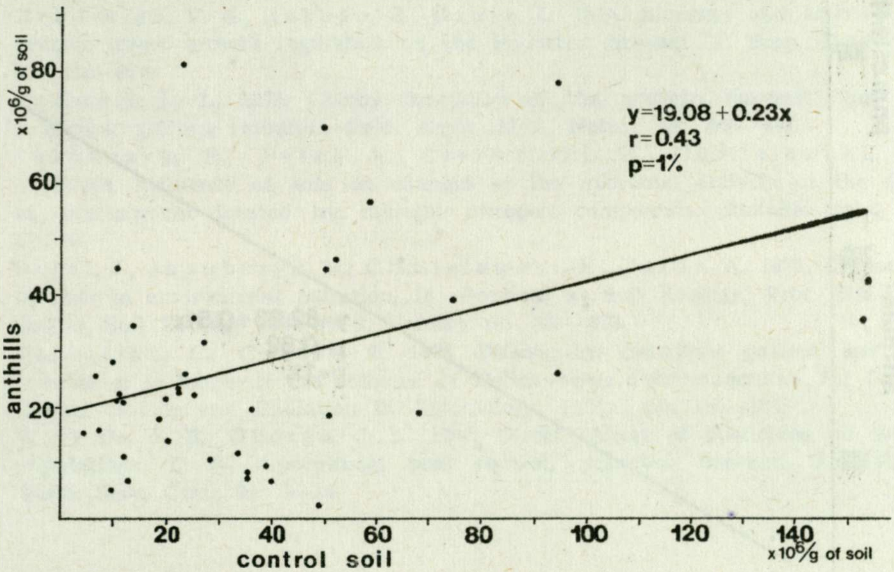

Fig. 6. Relationship between the numbers of microorganisms utilizing mineral nitrogen in the habitat and in the anthills of *Lasius niger* (L.) and *Myrmica* sp.sp.

The greatest differences are in the number of microorganisms utilizing mineral nitrogen. Their numbers in the habitat are 3.6—152.5$\times10^6$ cell/g of soil and are inversely proportional to N—NO_3 concentration in soil (Fig. 5). In anthills the numbers of these microorganisms decrease also in the gradient of pollution. But in places with the highest pollution the level is about 4 times higher than in the habitat (Fig. 6). Microorganisms utilizing mineral nitrogen are responsible for decrease of nitrate nitrogen concentration in soil. While the nitrate nitrogen amount in the habitat is 35—500 ppm it is 9—320 ppm in the anthills. The regression expressing the relation between N—NO_3 concentration in anthills and in soil is positive, but shows a considerable decrease in anthills situated in the zone of highest contamination (Fig. 7). This also causes higher pH in the soil of anthills.

CONCLUSIONS

Ant communities can survive under conditions unfavourable for other animals and plants. They limit the activity of workers and production in early summer, in the period when the pollution does not affect the biocenosis so badly. Also the ants initiate processes

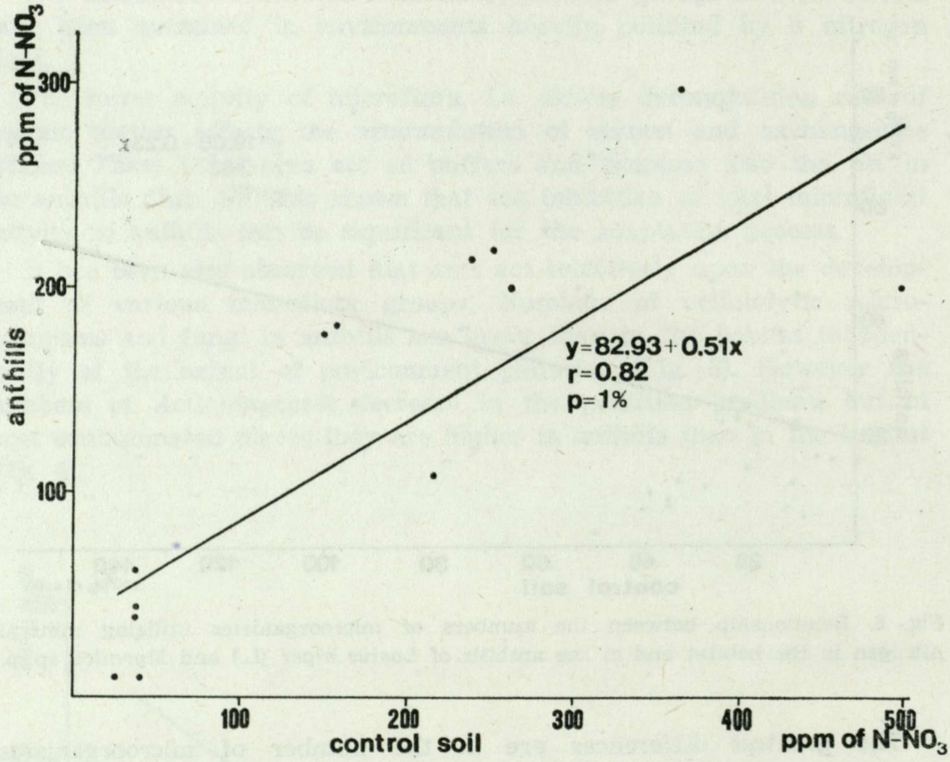

Fig. 7. Relationship between the content of nitrate in the anthills of *Lasius niger* (L.) and *Myrmica* sp.sp. and in the habitat

leading to a decrease in pollution concentration in nests. The soil of anthills is more buffered by limiting the total biological activity of soil, by accumulation of carbon and exchangeable cations. Buffering is also caused by varying humification—mineralization relations in anthills, namely intense growth of *Actinomycetes* and lower activity of fungi and cellulolytic organisms. Simultaneously ants can stimulate the growth of microorganisms removing the pollutants. The higher number of microorganisms utilizing mineral nitrogen is connected with lower $N—NO_3$ concentration in anthills. Thus the ability to produce biologically active compounds, modifying the development of microorganisms connected with social life of ants is an important scientific problem.

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REFERENCES

1. Bradleigh, V. S., Robeau, R., Dzuik, L. 1974. Bioassay and activity of several insect growth regulators on the imported fire-ant. J. Econ. Entomol., 67: 325—328.
2. Cadwell, L. L. 1973. Colony formation of the western harvester ant in a chronic gamma radiation field. Amer. Midl. Natur., 89: 446—448.
3. Jakubczyk, H.. Pętal, J., Czerwiński, Z., Chmielewski, K. 1973/1975. Influence of ants on changes of the microbial activity of the soil in environment treated by mineral nitrogen compounds. Bioindicatores, 2: 42—52.
4. Pętal, J., Jakubczyk, H., Chmielewski, K., Tatur, A. 1975. Response of ants to environment pollution. In: Progress in Soil Zoology, Proc. 5th Int. Colloq. Soil Zoology (ed. by J. Vaněk), pp. 363—373.
5. Torossian, C., Causse, R. 1968. Effects des radiations gamma sur la fertilité et la longevité des colonies de *Dolichoderus quadripunctatus*. In: C. R Colloq. Isotope and Radiation in Entomology, IAEA, pp. 155—164.
6. Witt De, J. B., George, J. L. 1960. Direct effects of pesticides on field populations: C — Agricultural pest control, imported fire-ant. U.S. Fish Wildl. Serv. Circ., 84: 7—14.

PRZYSTOSOWANIA MRÓWEK DO ZANIECZYSZCZEŃ PRZEMYSŁOWYCH

STRESZCZENIE

Zanieczyszczenia przemysłowe ograniczają wielkość zespołów mrówek, tj. liczbę gatunków, zagęszczenie gniazd oraz liczebność osobników w mrowiskach. Jednak w społeczeństwach mrówek występują procesy pozwalające im przetrwać w warunkach zanieczyszczeń, szkodliwych dla innych zwierząt i roślin. Mrówki ograniczają aktywność robotnic i czas rozwoju larw do okresu wczesnoletniego, kiedy skutki zanieczyszczeń są najmniej uciążliwe dla biocenozy. Jednocześnie inicjują procesy prowadzące do zmniejszenia stężenia zanieczyszczeń w gniazdach. Procesy te polegają na zwiększeniu buforowości gleby w obrębie gniazd poprzez ograniczenie ogólnej aktywności biologicznej gleby, kumulacji węgla i kationów wymiennych. Prowadzi do tego również zmiana stosunku humifikacji do mineralizacji w mrowiskach, przejawiająca się w uintensywnieniu rozwoju promieniowców i ograniczeniu aktywności grzybów i organizmów celuloitycznych. Jednocześnie mrówki stymulują rozwój mikroorganizmów usuwających zanieczyszczenia. Wzrost liczebności mikroorganizmów zużytkowujących azot mineralny wiąże się z obniżeniem stężenia $N—NO_3$ w mrowiskach.

ПРИСПОСОБЛЕНИЯ МУРАВЬЕВ К ПРОМЫШЛЕННЫМ ЗАГРАЗНЕНИЯМ

РЕЗЮМЕ

Промышленные загразнения ограничивают величину сообществ муравьев путем огра, ничения численности видов, плотности гнезд и численности особей в муравейниках. Однако,

в муравейниках наблюдаются процессы, которые позволяют муравьям пережить в условиях, вредных для других организмов. Муравьи активно способствуют процессам, ведущим к уменьшению фактора загрязнения гнезд:

— кумуляция углерода и фильтрирующих катионов;

— изменение соотношения гумификации к минерализации;

— стимулирование развития микроорганизмов, удаляющих загрязнения.